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THE sudden and mysterious death of Franklin B. Gowen removes a man who, a few years ago, was one of the most prominent figures among railroad managers. Although, since his retirement from the presidency of the Philadelphia & Reading Company three years ago, he had confined himself entirely to the practice of law, he was so active and brilliant a man and so much given to unexpected *coups*, that no one knew when he might return again to the railroad field. That he should die by his own hand, which seems to have been the case, was to his friends something altogether inexplicable, for he was not a man given to despondency, but, on the contrary, of an exceedingly sanguine and hopeful disposition, while he was also well provided with money and reasonably happy in his domestic affairs.

Mr. Gowen was never a practical railroad man, but rather a lawyer and a man of affairs, although his active and many-sided mind enabled him to grasp more of the practical part of railroading than most men of his class. Brilliant as he was, however, and successful as he was in many of his undertakings, his administration of the Reading's affairs must, upon the whole, be considered to have been a failure. He raised the Reading, it is true, from the rank of a successful local company to be one of the great railroad corporations of the country, but he brought it to bankruptcy and left it in a condition from which it will not recover in years, if, indeed, it ever does. In fact, his great weakness lay in the very sanguine disposition already referred to, which led him to anticipate too much from the future, and to take too little account of the obstacles to success. He was undoubtedly a man of the greatest ability, but the Reading stockholders might well have been satisfied with a less brilliant career than he had marked out for the company.

Personally, Mr. Gowen was an upright man, and his bitterest enemies never charged him with anything approaching a dishonest use of his position. His great strength was in his wonderful powers of persuasion, by which he retained so long his influence over the Reading stockholders and his position at the head of the company. Few men could resist him in a personal interview, and, when he was practising law, few cared to meet him at the bar.

A REMARKABLE time record was made on December 1 last on the Southern Pacific Railroad. On that day a special train, consisting of two cars containing officers of the Atchison, Topeka & Santa Fé Railroad, was run over the Southern Pacific lines from Bakersfield to Lathrop, a distance of 220 miles, leaving the former place at 9:01 and reaching the latter at 1:18; the total time was thus 4 hours, 17 minutes, but of this time 35 minutes were lost in making four stops and in slowing down on account of a broken frog at a station, making the actual running time for the 220 miles only 222 minutes, and it is claimed that even this could have been improved had not the road-bed been in poor condition, owing to recent heavy rains. It is claimed that this is the longest run ever made in this country at a speed of 60 miles an hour, and—speaking from memory and without consulting the records—we think that the claim is justified. The greatest speed attained for a single mile was betweeen Berenda and Merced, where one mile was made in 45 seconds, or at the rate of 80 miles an hour. The best time for a stretch of several miles was from Tulare to Goshen Junction, 10.5 miles, which, as shown by the despatcher's sheet, was made in exactly 8 minutes. Assuming the speed to have been uniform, this was at the rate of one mile in 45.7 seconds, or 78¾ miles an hour. This extreme speed was required to compensate for the slow time made in crossing the long bridges over the Kern, the San Joaquin, the Merced, the Tuolomne, and the Stanislaus rivers.

The engine which did this very fast work was an ordinary 8-wheeled locomotive with cylinders 17 × 26 in. and drivers 5 ft. 10 in. in diameter, built in the Sacramento shops, in 1885, from the designs of the late Mr. A. J. Stevens, and provided with his valve-motion. The engine burned 3½ tons of coal in making the trip, and the tank was filled twice with water during the run. Some careful work was done by the train despatchers in keeping the track clear for the special.

At Lathrop the train was taken by another engine of the same size, but the run beyond that point was not an extraordinary one, although still pretty fast, the distance from Lathrop to Oakland Pier, 90 miles, being covered in only 105 minutes, or at the rate of 51.43 miles an hour.

THE terminal facilities of the Baltimore & Ohio Railroad in Baltimore are to be very much improved when the arrangements which the Company has made are carried out. The first of these consists in the establishment of a great freight-distributing station at Berlin, Md., 70 miles from

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Baltimore, a place which has been selected because it is east of the junctions of all the branches and connecting lines of the system. The general distribution of freight, both east and west-bound, will be made here, and the yard, which will be arranged in the best manner, will be the central point for making all freight trains. This will greatly relieve the yards in and near Baltimore, and will take the distribution of freight entirely out of the city.

The second improvement will be by the construction of what is known as the Baltimore Belt Railroad, which will start from a point near Camden Station, thence by a double-track tunnel under the city to Jones' Falls, and thence to the eastern boundary of the city. It will connect the main line with the Philadelphia Division of the road without the present inconvenient transfer, and will enable both freight and passenger trains to be carried through and around the city without delay. It is understood also that it will serve as a connection with the Western Maryland and the Maryland Central Railroads, and with a large union station at a point much more convenient than the present Camden Station will be.

A NEW plan for the disposition of the Chicago terminal difficulties and for avoiding the delays now incident to the transfer of freight in that city is proposed by a corporation, organized under the name of the Chicago Union Transfer Company. This plan is to establish at a point south of the city, where convenient connections can be made with the Chicago & Western Indiana and the Outer Belt railroads, a series of extensive yards connected by a circular railroad. To these yards all transfer freight would be brought, and all switching would be done there, the amount of switching being reduced to a minimum, the transfers promptly made, and the present delays and inconveniences wholly avoided. The Transfer Company would also act in the capacity of a clearing-house to conduct the business between the different companies. The plan seems a very feasible one, and there is no doubt that it can be carried out successfully, provided all the railroad companies concerned give their assent; several, it is said, have already done so. Some such arrangement as this is really essential to the proper conduct of business at Chicago.

IN Sweden and Norway, as in many other countries, there has been much activity in railroad building for the last two or three years, both from private enterprise and by the Government. The Swedish Parliament has more than doubled the annual grant for the construction of new lines in 1890, and work is proceeding rapidly on several important roads, especially on those extending to the northern part of the kingdom and intended to develop the resources of that section, which has hitherto been somewhat neglected.

THE latest country to enter the field as a builder of railroads is Siam, as will be seen from an article published in another column. Heretofore there have been no steam railroads in that country, and the only line of any description has been a street tramway in the city of Bangkok.

As will be seen from the article, it is proposed to begin in a moderate way, and there is every reason to hope for the success of the Borapah Railroad Company, which is the pioneer in the work. It is to be regretted that from present indications the orders for material and rolling stock will go to European manufacturers, as a new field might be opened to our own car and locomotive-builders, which in time might prove to be of considerable value to them, as the country is capable of much development.

THE truth about Chinese railroads, which, as was noted in our last number, has been somewhat difficult to get at, seems to be that for the present railroad construction is stopped, the conservative and anti-progressive party, which is strongly opposed to foreign loans and to the introduction of foreign methods, being temporarily in the ascendant at Pekin. From accounts received from China, it seems that this party has taken advantage of the accidental destruction of the Temple of Heaven by fire started by lightning, to excite the superstition of the Emperor and his chief councillors, and that this accidental fire has been interpreted as a visitation of divine vengeance, consequent upon the imperial order sanctioning the building of railroads. The superstition inherent in the Chinese character has thus been used shrewdly by the conservative leaders to further their purposes.

The sanction for the construction of the railroad, it appears, has not yet been formally revoked, but the whole question is, for the present, in abeyance. The progressive party, headed by the Viceroy Li, may be relied upon, however, to make every possible effort to secure the construction of the railroad; but for the present it is very doubtful whether they will be able to do anything.

THE decision—or rather opinion—of the International Railroad Congress does not seem to have been altogether favorable to the compound locomotive. That opinion, which will be found on another page, was to the effect that while a certain success has been attained with compound locomotives, it is not yet by any means sure that the economy in fuel which has been secured is not counterbalanced by the disadvantages inherent to the greater complication of the machinery and by the extra cost for repairs and lubrication. The Congress, however, admitted that there might be a balance upon the right side in countries where fuel is expensive, and advised a continuance of the experiments, so that the question may still be considered an open one.

AS will be seen from the extracts from his report, which are published on another page, the present Secretary of the Navy does not favor any considerable increase at present in the number of cruisers in the Navy, but thinks that its further development should be in the direction of heavy armored battle-ships adapted to fight for the defense of the coast. A battle-ship is of use only for naval purposes, but for cruisers, he thinks, fast vessels can be supplied in case of war from a naval reserve—that is, from merchant ships, so built that they can be armed and used as cruisers when required. There are strong arguments in favor of this plan, and the chances are that it will at least be given a trial.

IT is understood that the Navy Department is considering a change in the armament of the coast-defense vessel, which is now under construction at the Union Iron Works in San Francisco. The original design provided for one 16-in., 110-ton rifled gun in the forward turret; one 12-in.,

46½-ton gun in the after turret; and a 15-in. Zalinski dynamite gun forward. It is now proposed to substitute two 12-in. guns for the 16-in. gun in the forward turret, and to use a 10-in. instead of a 12-in. gun in the after turret. It is possible also that the dynamite gun may be omitted. These changes have not been finally decided upon, but are under consideration.

Experience with the 110-ton guns in England has not been sufficiently encouraging to warrant the introduction of these very large guns. They are exceedingly expensive, and it appears to be a very general opinion among foreign naval authorities that these enormous guns are of very doubtful utility, and that in most cases better service can be done by two or three guns than by one of the largest size.

THE Secretary of the Navy has ordered that the new coast defense vessel now building in San Francisco shall be called the *Monterey*, that name being chosen because Monterey was the point where the United States flag was first raised in California.

The new torpedo-boat will be named the *Cushing*, in memory of Lieutenant Cushing, who first demonstrated, on the Confederate iron-clad *Albemarle*, at Plymouth, N. C., the power of a torpedo attack.

NAVY bills are already plenty in Congress, and the first one, which has been introduced in the Senate by Mr. Hale, of Maine, provides for the construction of no less than 18 new ships. In accordance with the ideas laid down in the report of the Secretary of the Navy, no more cruisers are included in the number, which is made up of eight heavy armored ships of from 7,500 to 10,000 tons displacement; two armored ships for coast defense; three gunboats of from 800 to 1,200 tons displacement; and five torpedo-boats of the first or sea-going class. How far this programme will be approved by Congress remains to be seen.

ANOTHER bill, introduced by Mr. Hale, is also apparently based upon the Secretary's report, and provides for establishing a naval reserve of merchant vessels built in accordance with the requirements of the Government, and of sufficient engine power and stability to carry guns, and to be used as cruisers in time of war. The compensation proposed for building ships in accordance with these requirements is a percentage payment for "trouble and expense incurred in complying with the conditions of the Government." We do not give any fuller statement of these bills, as they will probably be modified considerably before their passage.

THE Ordnance Department of the Army proposes to make extensive improvements at the Watervliet Arsenal this year, and has asked for appropriations of $249,000 for completing the building for the large gun factory, and $888,500 for machine tools, cranes, etc., for the factory. With this additional plant six 16-in. and ten 12-in. guns can be turned out yearly in addition to the smaller guns now manufactured. Should the appropriations be obtained it is thought that the Arsenal can be ready to make 16-in. guns by the time the forgings for those guns could be delivered.

Besides making the new guns the Department proposes to continue the alteration of the old 15-in. guns and the conversion of the 10-in. guns into 8-in. rifle cannon, with the alteration of the old carriages for the more modern guns. It is also proposed to continue the experiments with armor-piercing projectiles, and with smokeless powder.

THE building of new ships for lake business is very active this fall, nearly ~~all the~~ ship-yards on the lakes being busy, and in Cleveland alone 15 large steamers are under contract, 12 of them being of steel. Nearly all of these vessels are intended for ore and grain carriage, and are of the type common of late years on the lakes, with great capacity for cargo, and with machinery of the latest and most economical type, the engines being generally of the triple-expansion pattern.

In one respect there is a new departure this fall, Wheeler & Company, of Bay City, having undertaken to build two steamers for ocean service. These ships are to be of steel, to have a capacity for 3,000 tons of cargo each, and are built for the Chesapeake & Ohio Railroad Company, to run from Newport News. They will be built in sections so as to pass readily through the Welland and the St. Lawrence canals.

THE NEW YORK CENTRAL ACCIDENT OF SEPTEMBER 27, 1889.

IT will be remembered by most of our readers that an accident occurred some months ago on the New York Central Railroad, which was caused by the second section of the fast Chicago express running into the rear end of the first section near Spraker's Station, and that four persons were killed and eight were injured. We omitted making any comment thereafter because the subject was under investigation by the Railroad Commissioners of New York State. The Commissioners made their report on November 12, but for some reason a copy of it did not reach us before the December number of the JOURNAL went to press. Although our comments thereon are somewhat belated, we will, nevertheless, have our say.

The train was made up as follows: 1. Locomotive; 2. Baggage car; 3. Coach; 4. Coach; 5. Coach; 6. Sleeping car; 7. Special car *Kankakee*; 8. Michigan Central private car.

The Commissioners report that:

> The second section crashed into the end of the private car of the Michigan Central road. The rear of this car, for about 10 ft., was fitted up as an observation room, and was crushed through about 8 ft. The remainder of the car, owing to its unusual strength, was comparatively uninjured. The car ahead, the *Kankakee*, occupied by the President of the Cleveland, Cincinnati, Chicago & St. Louis Railroad and others, was injured comparatively little. It appears that *the rear end of this car was pressed down, tilting up the forward end, which telescoped the sleeping car ahead of it.** The *Kankakee* was some 8 or 10 in. narrower than the sleeping car. If the frame of the *Kankakee* had been the same width as that of the sleeping car, it is probable that little or no injury would have been done. As it was, however, the resistance that it met was only from the interior construction of the sleeping car. The dead and the wounded were all found in the latter car, except the porter of the *Kankakee*, who was in the forward part of that car, and was killed when the telescoping took place.

The Board concluded that the principal cause of the accident "was the rule of the New York Central & Hudson River Railroad Company, permitting these sections to

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* Italics ours.—EDITOR JOURNAL.

be run at as close an interval as five minutes; . . . and the Board is of the opinion that the interval of time is too short."

They recommend that the interval be made 10 minutes, that the Railroad Company take into consideration the subject of equipping the entire line with block signals, and that brakes be applied to all the wheels of six-wheeled trucks.

The Railroad Company would do well to act in accordance with these recommendations, but some of its officers, and perhaps the Railroad Commissioners also, might do well to heed some of the recommendations of the RAILROAD AND ENGINEERING JOURNAL.

In the JOURNAL for February, 1887, we published the following description of the Blackstone platform:

when one car adjoins the other, as shown on the right side of fig. 4, the safety-beams interlock, as shown. It will also be seen that those in the one car project under the buffer-beam of the other, so that the one car cannot raise up without taking the other with it. In this way the floors are kept in line, and the longitudinal beams, instead of one side only, must resist the shock of collision. The side has little more capacity of doing so than the paper in hoops has of opposing the leaps of a circus-rider.

These horn timbers were invented by Mr. Blackstone, President of the Chicago & Alton Railroad Company. As safety-guards, in case of accident, they appear to have as much value as the Miller platform, although there is no reason why they should not be used conjointly. Probably if Mr. Blackstone had urged the adoption of his invention with the same vigor, and with the same methods, that were employed to make the Miller platform known, the former would now be as generally used as the latter is. There is little doubt that if the Blackstone device had been adopted, we would have been spared the horrors of some of the accidents that have occurred in recent years.

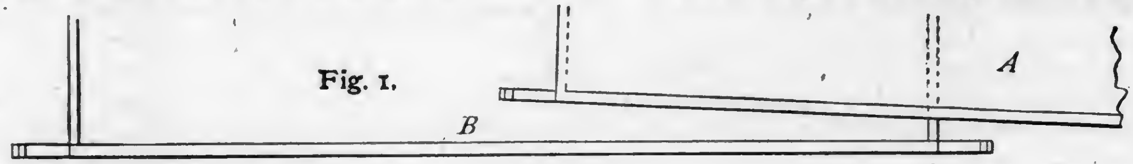


Fig. 1.

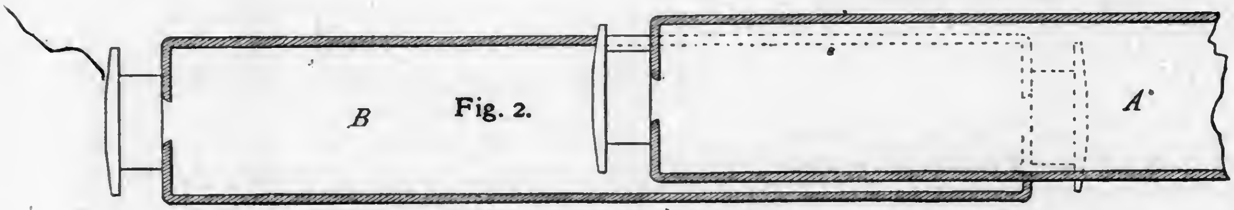


Fig. 2.

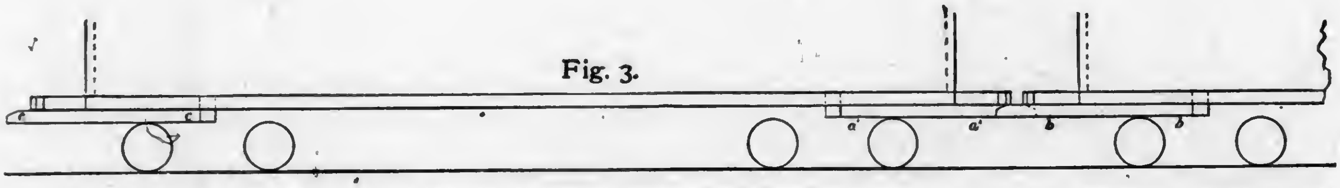


Fig. 3.

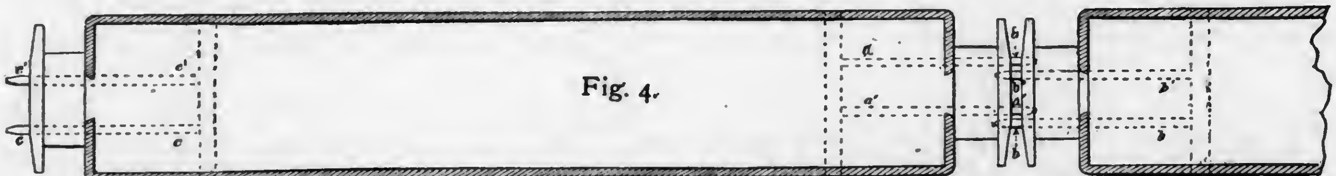


Fig. 4.

It was supposed that when the Miller platform was introduced it would entirely prevent the telescoping of cars; but recent accidents have shown that such is not the case. No doubt the Miller platform will resist shocks which would have crushed the old-fashioned cars which were used before it was introduced; but what generally occurs in collisions now is that the floor of the one car mounts above that of the other, as shown in fig. 1. The position of the two car bodies is shown in a plan view in fig. 2. It will be seen that when the cars get into this position, the only thing which resists the car *A* from crushing or telescoping with *B*, is the side *s s*. This consists of posts and panels and has very little strength. If, however, the floors of the cars could be kept in line, or the one be prevented from raising above the other, then the shock would be resisted by the longitudinal sills in the floor, which have a great deal of strength. What is needed, therefore, is some device to keep the floors of the cars in line, and prevent the one from raising above the other. Happily, we have not far to go to find such a device. The Blackstone platform and coupler have been in use on the Chicago & Alton Railroad for some 15 years or more. Of the coupler no other mention need be made. The peculiar feature of the platform referred to is shown by fig. 3, which is a side view, and fig. 4, a plan of the floor framing. Each car has two "horn timbers," *a a*, *a' a'* and *b b*, *b' b'*, which project beyond the buffer-beams, and are fastened below the floor-sills. The horn timbers are not placed at equal distances from the center of the car, but one is farther from it than the other, so that

In the May number of the same year a complete engraving of this invention was also published, with the following comments:

A common impression prevails that Miller platforms are an effectual preventive of telescoping. Many accidents have shown that such is not the case. The Miller platform has very little, if any more, capacity to resist concussion if the cars are not kept in line with each other than the old-fashioned cars had. The only thing which prevents cars with Miller platforms from mounting on top of each other in collisions is the draw-hook, and this is usually so insecurely fastened that it has comparatively little strength. The "horn timbers" which Mr. Blackstone has devised can be made with any amount of strength, and, it is believed, would do as much to prevent telescoping as the Miller platform has or will. Probably a good many more lives will be sacrificed before the value of this device will be generally recognized. It would not require very great prescience to prophesy that other horrible accidents will occur in the not very remote future, in which a good many lives will be sacrificed and which will cause inexpressible suffering—all of which might be prevented by the adoption of the simple device illustrated in the engravings, and which any company is now at liberty to use.

The last sentence might appropriately be set up with the following heading:

PROPHECY

From the Railroad and Engineering Journal of May, 1887,

and be held in reserve for publication when other accidents of a similar character occur, as they surely will. The Commissioners have asserted that "if the frame of the *Kankakee* had been the same width as that of the sleeping car, it is probable that little or no injury would have been done." With equal assurance we may say that it is more than "probable" that, if the three rear cars had been equipped with Blackstone's "horn timbers," there would have been no loss of life. If their cost is urged as a reason for not using them, the objection is not valid, so long as railroad companies can afford to append the preposterous vestibules to cars to prevent dudes and fine ladies from soiling their kid gloves in going from one car to another. The vestibules weigh and cost many times more than the "horn timbers" would, with the difference, that the principal purpose of the first is to gratify a love of ostentation in travelers and railroad officers, whereas the last would serve the blessed purpose of saving human life and preventing the most terrible suffering.

INTERNAL NAVIGATION IN FRANCE.

ATTENTION has heretofore been called to the fact that while in this country the water communications are being gradually superseded by the railroads, in Europe there has been during the last 20 years a very notable revival of interest in the waterways, natural and artificial, and the attention of Governments and engineers alike has been turned to their improvement and extension.

The United States has a system of navigable rivers and lakes unsurpassed in any country in the world, and it has at different times expended large sums in their improvement and in building canals to connect them and complete the system. Railroad competition, however, has taken away a considerable share of the business which formerly sought the Mississippi, the Missouri, the Ohio, and other rivers, and even threatens the great line of communication by the lakes and the Erie Canal, while nearly every one of the less important rivers is paralleled by a railroad line.

Our artificial waterways have actually diminished in number. The old Wabash & Erie Canal and the canal which once connected the Allegheny River and Lake Erie have disappeared; the James River & Kanawha Canal is now a railroad; the Chesapeake & Ohio, the Morris, and the Pennsylvania Canals are threatened with a like fate, while no new canals of importance have been built for years past and none are now under construction.

A notable instance of the opposite tendency in Europe is found in the exhibit made by the French Bureau of Internal Navigation at the Paris Exposition, and some account of the past and present state of the internal waterways of France may be of interest. It must be stated at the outset, that there are in that country no rivers of the size that we possess, and few that were originally navigable for vessels of any size.

It may be said that canals of any length first became possible about the beginning of the sixteenth century, when the invention of the lock was made almost simultaneously by French and Dutch engineers. The age was not favorable to the development of the idea, however, and the first canal undertaken in France was the Briare Canal, connecting the Seine and the Loire through the Loing Valley. Planned in 1604 by the engineer Hugues Cronier, under Henry IV., and his great minister, Sully, this work was not completed till 1642. It was followed by some others of small importance, but it was not until the seventeenth century that the great engineer Pierre Paul Riquet built the Canal de Languedoc, which completed a water-line from the Atlantic Ocean to the Mediterranean. Political reasons delayed the development of the system, and it was only in 1793 that the Canal du Centre, connecting the Saone and the Loire, was opened.

At the beginning of the nineteenth century there were in France about 625 miles of canals, varying widely in size and capacity, while the usefulness of these was restricted, owing to the entire lack of any works of improvement on the rivers, the navigation of which was everywhere obstructed by bars, rapids, shoals, and, above all, by the variable depth of water found at different seasons. Such works were not then in favor, and more than one prominent engineer believed with Brindley, that rivers were created chiefly to feed canals.

The condition of affairs was such that a prominent French engineer remarked that if canals had filled the gaps between the rivers, in their turn the rivers now formed gaps between the canals.

Little or nothing was done to remedy this state of affairs until after 1830, when the Government of Louis Philippe entered upon a work of improvement, which was much facilitated by the invention of the movable dam by the engineer Poirée in 1834. This made it possible to regulate the stage of water and to store up the spring floods in the rivers for use in the summer droughts. The first important works of this kind were completed in 1838, at the rapids of Bezons in the Seine, at Epineau in the Yonne and at Decizes in the Loire.

In the succeeding 10 years the development of internal navigation was rapid, the works of this period including the improvement of the Seine, the Aisne, the Saone and the Garonne, and the completion of such important canals as the Marne-Rhine, the Nantes-Brest, the Nivernais, the Berri, the Bourgogne, and the Garonne lateral.

About 1848 the railroad era was well begun, and for the next 12 years the capital contributed by Government and private enterprise was chiefly devoted to the building up of the railroad system of the country, to the neglect of its waterways.

In 1860, however, interest in the latter revived, but for the ensuing 10 years efforts were directed rather to the improvement of existing lines than to the building of new ones. In 1870 several new works of importance were undertaken, such as the canalization of the Upper Seine, the improvement of the Lot, the building of the St. Louis Canal, and finally the extensive works for the improvement of the navigation of the Rhone.

In 1878 the Government undertook to establish some uniform standard by which all internal navigation works should be governed, and at the same time laid down an extensive programme for future work. The minimum dimensions then adopted for all canals and river improvements were as follows: Depth of water, 2 meters (6.56 ft.); width of locks, 5.20 m. (17.06 ft.); length of locks, 38.50 m. (126.28 ft.); clear height under bridges, 3.70 m. (12.14 ft.). These dimensions were chosen as permitting everywhere the passage of the type of boat

most widely in use, which can carry about 300 tons of freight.

The work of carrying out this uniform system has been prosecuted diligently, as will be seen by the table below, which gives the length of waterways conforming to the Government system in 1878—the date of its adoption—and in 1887, in miles :

	1887.	1878.	Increase.
Canals	1,086	288	798
Canalized rivers	1,130	618	512
Total	2,216	906	1,310

This work required the improvement and extension of many of the older canals, but it was not permitted to interfere with the building of new canals or with the improvement of rivers heretofore untouched. Much of this kind of work has been done, so that the system of internal waterways has been considerably extended as well as brought to a uniform standard, which permits a boat conforming to the required dimensions to pass all over France.

The most difficult and important undertaking now in progress is the improvement of the Rhone, a river hard to control on account of its rapid current, its great variations in flow, and the large quantity of sand and débris which it brings down in the spring floods.

The exhibit made at Paris includes plans and drawings, models of locks and dams, and of dikes and other works, so arranged as to give not only an idea of the present means employed, but also an historical view of the work of the engineers who have controlled the internal navigation of the country.

In this connection it may be noted that the French engineers consider that the most important invention of recent years is the hydraulic lift or lock, which enables them to overcome by a single lift differences in level which formerly required several locks, and which also requires much less water, often an important consideration. Next to this is the use of the pneumatic caisson for building foundations under water, which permits them to undertake works formerly considered impossible, and greatly reduces the cost of such operations.

The great object to be sought for in the future is some method of mechanical traction to take the place of horses, and in this connection their chief hope seems to be in some form of cable towing, though it is admitted that a system which will fill all the requirements has not yet been developed.

The French engineers recognize fully the importance of the waterway in competition with the railroad, both as a carrier of heavy freights and as a regulator of rates. In this connection we cannot do better than to quote the words of M. Fleury, to whose admirable paper before the Conference on Internal Navigation at Paris we are indebted for many of the facts given above :

" Finally, it is a necessity, which continually grows more imperative, that the national industry should have the cost of transportation of its products reduced to the lowest possible point. The duty which is to-day imposed upon us, as engineers, is to secure cheap transportation by improving the existing system of internal navigation and by completing it to the fullest extent which our resources will permit ; and as managers, to realize—if that be possible—such a division of traffic between the railroads and the waterways as will permit without conflict, the complete utilization of both these instruments of transportation, both alike indispensable to our prosperity."

NEW PUBLICATIONS.

CRAM'S STANDARD AMERICAN ATLAS OF THE WORLD ; ACCOMPANIED BY A COMPLETE AND SIMPLE INDEX OF THE UNITED STATES : COMPILED BY GEORGE F. CRAM. Chicago and New York ; George F. Cram (price, $10.50).

An atlas is really as necessary to the intelligent man as a dictionary—that is, a good atlas—a poor one is worse than worthless. The one now under consideration belongs to the first class, and, though a first examination cannot be expected to show all the merits and defects of so large a work, it is sufficient to reveal its general quality.

From such an examination it can be said that the maps are generally clear and well printed. Those of the United States are on a large scale, so that even the small villages can be found ; if they err, it is rather on the side of too great minuteness of detail, which can hardly be called a great fault. They are brought very generally up to date, from the best attainable sources of information, an important point when the map changes as rapidly as it does nowadays, and the information given appears to be from the latest accessible sources. Where a State is so large that it is necessary, in order to preserve the general scale, to divide the map into two sheets, it is always followed by a map on a smaller scale, giving the entire State on a single sheet ; this may seem unnecessary, but it is really in many cases a very great convenience. A minor matter, which is also a convenience, is the printing on the margin of each map the pages on which the maps of the adjoining States or countries are to be found—cross-references which often save the time spent in turning over a number of pages, or a reference to the index.

The Index to the United States, arranged by States, gives a list of the railroads in each, and also of all the towns, villages, post-offices, and railroad stations. For the convenience of shippers and correspondents there is added a list of telegraph-offices and money-order offices, and the name of the express company doing business over each railroad line.

Including a number of statistical tables and diagrams, the atlas contains 402 pages ; there are 129 separate maps of States and countries and 30 of cities. The book is well executed mechanically, and the compilation seems to have been done with great care.

STEAM : BY WILLIAM RIPPER. London and New York ; Longmans, Green & Company (price, 80 cents).

The title of this book does not indicate its real character. While a portion, although a small one, is devoted to a consideration of the nature and effects of heat and the properties of steam, it is, in fact, an elementary treatise—and a very good one—on the steam-engine.

The question which a mechanical editor is called on to answer probably oftener than any other is that which comes from students, apprentices, and mechanics—" What is the best elementary book on the steam-engine ?" To be compelled to say that there is no good one, seems like heaping discouragement in the path of ambition, which is, perhaps, taking its first halting steps. Happily since the admirable book of Mr. George C. V. Holmes has been written, and the one by Mr. Ripper, which we are reviewing, has appeared, a conscientious editor is no longer obliged to rate books on the steam-engine, as the lamented President Lincoln did some of the Kentucky Baptists, as being too good for destruction, but too bad for salvation. Mr. Holmes speaks of his book as an " elementary text-book," which perhaps describes it as well as any other designation could ; nevertheless, parts of it are tough reading for a beginner, especially if he has had few advantages of early education. While it is an admirable book, and one whose merits are not nearly as well

known in this country as they should be, still, an easier and simpler one was needed to put into the hands of beginners. This want is admirably supplied by the book before us. The general character and scope of it will be indicated by a summary of its contents: The first three chapters are on Heat, the fourth on Combustion, the next four on the Properties and Expansion of Steam. The tenth is a general description of the Steam-Engine, which is followed by chapters on the Slide-valve and Valve-gear, Cranks and Crank-shafts, Condensers, Governors, Compound Engines, Boilers, and Practical Notes on the Care and Management of Engines and Boilers.

The descriptive matter is admirably clear, and the Author seems to have that rare faculty of understanding his subject thoroughly, and then being able to assume the mental attitude in relation to it which a person who does not understand it must occupy. He has resisted, too, the temptation which few professors seem able to withstand—that is, of showing how easy it is for them to use mathematics. The calculations in the book are either all arithmetical or else only the simplest use of algebraic notation is employed.

Less than six pages are devoted to locomotives, which seems too small a portion considering how great the interest in that class of engines ordinarily is. If that amount of space was all that was available, it would seem as though something of more interest and importance could have been given in it instead of the information that valve-spindles are of best Yorkshire iron, and the guide-bars of the best mild crucible cast-steel.

The chapter on Compound Engines is very timely, as there is now so little of an elementary character within reach of a student.

The book is well up to modern practice, and in his preface the Author says that "the rapid progress made in engineering science during recent years, and the limited space at disposal have necessitated the omission of descriptions of obsolete types of steam-engines," for which the reader may be thankful.

The engravings are made by some kind of process. They are generally fairly good, but the lettering on some of them is inferior to the other mechanical work of the book. It has 200 pages, and sells for less than a dollar. The apprentice or mechanic in a machine-shop will make a good investment of the price of the book by buying and studying it.

THE COSMIC LAW OF THERMAL REPULSION: AN ESSAY SUGGESTED BY THE PROJECTION OF A COMET'S TAIL. New York; John Wiley & Sons, No. 15 Astor Place. (Price, 75 cents.)

This somewhat enigmatical title is not made much clearer by the Preface, which is as follows:

> This essay embodies ideas the development of which has afforded the Author much pleasant mental recreation. Their consideration may not convey to other amateurs the pleasurable excitement of original pursuit; but all who are trying to unlock the mysteries of nature will find in them interesting suggestions; and it is hoped that they may excite inquiry which will lead to a substantial advance in scientific knowledge of the Constitution of Nature.

The object of the writer is, apparently, to prove that repulsion—or, rather, thermal repulsion—is of equal importance with attraction—cohesion and gravitation—as a force of nature, and in determining the present constitution of the world and the phenomena of the universe. The essay is, apparently, carefully studied and worked out, and will be worth reading by all those who, as the Author says, are fond of original investigation.

THE CITY OF ELIZABETH, N. J., ILLUSTRATED. Elizabeth, N. J.; published (under the auspices of the Board of Trade) by the *Daily Journal* Printing House.

This book is published to set forth the attractions of the city which it represents to manufacturers as a site for their establishments, and to others as a place of residence. These advantages are the long water-front; direct water outlet to the harbor of New York; nearness to and frequent communication with New York by rail; the passage through the city of two trunk lines—to which a third will soon be added—giving rail connections of the best kind, with cheap supplies of coal, iron, etc.; and, for residents, schools, churches, and other conveniences not always found in a suburban town.

The book is worthy of mention, and is distinguished from many other publications of the same kind by the notable excellence of the work done on it. The illustrations are remarkably well done, and many of them are notably good representations; the descriptive matter is good, and while it, of course, praises the city, is free from the too open puffs often met with.

The mechanical execution is very good and reflects great credit upon the publishers, showing that, in this industry at least, Elizabeth is fully up to the times.

BOOKS RECEIVED.

A MANUAL OF INSTRUCTION FOR THE ECONOMICAL MANAGEMENT OF LOCOMOTIVES, FOR LOCOMOTIVE ENGINEERS AND FIREMEN: BY GEORGE H. BAKER. Chicago; Rand, McNally & Company.

AMERICAN RAILROAD BRIDGES: BY THEODORE COOPER. New York; *Engineering News* Publishing Company. This profusely illustrated paper, reprinted from the *Transactions* of the American Society of Civil Engineers, appears in the form of a book of 60 pages, with a number of inset plates. It is received too late for full comment in the present number.

THE RETURN OF POWER IN ELECTRIC AND CABLE TRACTION. THE RAPID TRANSIT CABLE COMPANY'S CABLE TRACTION SYSTEMS FOR STREET AND ELEVATED RAILROADS: BY ANDREW BRYSON, JR. New York; published by the Author.

LOCOMOTIVE DEVELOPMENT: COMPILED BY CLEMENT E. STRETTON, C.E. Leeds, England; issued by the Associated Society of Locomotive Engineers and Firemen, as a special number of its *Monthly Journal*.

GEORGIA SCHOOL OF TECHNOLOGY, ATLANTA, GEORGIA: ANNUAL CATALOGUE AND ANNOUNCEMENT FOR 1888–89. This School is a department of the University of Georgia, and although only organized in 1888, it has already a considerable number of students and is well equipped for its work in the several departments. The leading course is in Mechanical Engineering, but there are also courses in Geology, Physics, and Chemistry, with, of course, instruction in Mathematics, Drawing, English, etc.

TENTH ANNUAL REPORT OF THE OHIO SOCIETY OF SURVEYORS AND CIVIL ENGINEERS: BEING THE TRANSACTIONS OF THE SOCIETY AT ITS TENTH ANNUAL MEETING, HELD IN COLUMBUS, O., JANUARY 8, 9, AND 10, 1889. Columbus, O.; published for the Society.

PRATT INSTITUTE RECORD: FOUNDER'S DAY NUMBER. Brooklyn, N. Y.; published by the Pratt Institute.

ILLUSTRATED SUPPLEMENT TO THE CATALOGUE OF THE BROWN & SHARPE MANUFACTURING COMPANY. Providence, R. I.; issued by the Company.

CORNELL UNIVERSITY, COLLEGE OF AGRICULTURE: BULLETIN OF THE AGRICULTURAL EXPERIMENT STATION. Ithaca, N. Y.; published by the University.

WOOD-WORKING MACHINERY: ILLUSTRATED CATALOGUE. Philadelphia; L. Power & Company, 12–20 South Twenty-third Street.

RAILROAD SAFETY APPLIANCES, PARSONS'S PATENTS: CATA-

LOGUE AND DESCRIPTION. New York; issued by the Parsons Block, Switch & Frog Company, No. 29 Broadway.

SCREW MACHINES MADE BY THE BROWN & SHARPE MANUFACTURING COMPANY: ILLUSTRATED CATALOGUE. Providence, R. I.; issued by the Company.

ABOUT BOOKS AND PERIODICALS.

AMONG the articles in the CENTURY for December is one on the New Croton Aqueduct, which is illustrated, and gives many interesting facts in relation to that important engineering work.

In the SCHOOL OF MINES QUARTERLY for November we find articles on Maintenance of Track, by Thomas J. Brereton; on Multiple Expansion Engines, by G. Sydney Percival, and several others of much technical and special value.

The Scientific Publishing Company, of New York, announces the publication—by special permission of the British Institution of Civil Engineers—of the very valuable work on MINING ACCIDENTS AND THEIR PREVENTION, by Sir Frederick Augustus Abel, which is considered the highest authority on this important subject. In addition to the original memoir, the book will contain a compendium of the laws relating to coal-mining in the United States, Germany, and Great Britain, making it a work really indispensable to mine operators.

The electrical articles will be continued in SCRIBNER'S MAGAZINE, and in addition there will shortly be published several articles on the life of the late Captain John Ericsson. The January number gives an illustrated article on Water Storage in the West, which is timely, in view of the general interest felt in the question of irrigation. This article contains views of several of the important dams recently built in Arizona and California.

A new monthly journal has appeared in Chicago under the name of ELECTRICAL INDUSTRIES. Its object is to deal rather with the practical applications of electricity than with its scientific problems. The opening number contains a variety of information. It is as attractive in appearance as clear type, good paper, and excellent press-work can make it.

A new venture among the magazines is the ARENA, published in Boston. In its first number it presents discussions by high authorities of some leading issues of the day. Its object, indeed, is the discussion of moral, social, and economic questions in the most free and liberal manner possible.

In the OVERLAND MONTHLY for October James O'Meara champions the cause of the American Pacific roads against the Canadian Pacific. An article on the Supplanting of Steam, by Alvan D. Brock, is a well-considered paper on the uses of electricity in transmitting power, and the many places in which it can be applied to utilize the force of the many mountain streams of California, which are now wasted, because they are remote and generally in places where sites for mills and factories cannot be found. With electrical transmission the power of these streams can be conveyed to points where it can be used conveniently. This is a question of peculiar importance on the Pacific Coast, where coal is scarce and high in price.

In the POPULAR SCIENCE MONTHLY for December Professor Henderson continues his articles on Glass-Making. Dr. Hilber's article on the Struggle of Sea and Land is worthy of note, and there are several others of much interest. In the January number Henry J. Philpott discusses Irrigation in the Far West, giving some account of what has been done in this direction, with the effects on methods of agriculture and general conditions of the country.

The STEVENS INDICATOR for October has several interesting articles, including one on the Steam Turbine, one on Courses in Experimental Mechanics, and a note on Performance of the Steamer *Homer Ramsdell* on the Hudson River.

ENGINEERING IN THE FAR EAST.

OUR correspondent in Siam, who is engaged in engineering work in that country, sends us some interesting particulars with regard to the first railroad there. The concession for this line has been obtained from the Government and the company organized. The names of the directors chosen indicate that this is to be supported by a combination of native and foreign capital. The list of these directors is as follows: H. R. H. Krom Koon Narit; T. R. H. Krom Mun Damrong, Phra Ong Chow Warawan, Krom Mun Sammot, Krom Mun Sanprasah, Krom Mun Putaret; H. H. Prince Prisdang; H. E. Phya Samuth, H. E. Phya Nakanaisee; Messrs. Choem Sri Sriraraks, P. Gowan, J. McCarthy, H. Sigg, F. Clarke, A. J. Loftus, A. de Richlieu.

The Company is known as the Borapah Railroad Company, and the name seems to be appropriate, as we are informed that it means not only first of its kind, but also east or eastern, both names being very appropriate. The capital stock is 800,000 ticals (about $480,000), and is to be raised by local subscription. The line will extend from Bangkok, the principal city of the country, eastward to Paknam and Patriew, a distance of about 50 miles, and is to be one meter gauge. The road-bed will be constructed by local contractors, but the rails and rolling stock will be ordered from Europe, although the orders have not yet been placed.

The country along the proposed line is generally level, with no large rivers to be crossed, so that no particular engineering difficulties are presented. Stone for ballast and other purposes can be obtained in the neighborhood of the line, and there is abundance of the best timber. The country through which the road will pass is represented as very fertile. The freight will include rice and other agricultural products, teak and redwood timber. The passenger traffic is expected to be large, as the Siamese are great travelers and are very fond of using all sorts of public conveyances. The only railroad now in the country is the street railroad or tramway in Bangkok.

Concerning this road, our correspondent writes as follows: "Patriew is about 50 miles due east from Bangkok, and the line will probably be obtained without delay. The concession also touches Paknam, a possible port near the mouth of the Meinam River. While the Borapah Railroad is likely to be rather a slight affair, it surely will be much better than a wildly extravagant plunge, such as some hundreds of miles of a trunk line paralleling the river, which affords very fair transport facilities.

"It is now (October) the rainy season here, when, according to all precedents, we should have died for our temerity in being here in the great 'Jungle of the God of Fire.' We have no serious sickness, however, and the bad reputation of much of Siam results mostly from the indolent habits and dense ignorance of the people. I keep all of my men under canvas, insist on their taking the trouble to keep their beds dry, and give them a little quinine daily. The best remedy for fever is Warburg's tincture, now put up in pills also; quinine is an efficient preventive.

"It is expressive of present transport facilities away from the Meinam River that rice is worth $\frac{3}{8}$ tical ($22\frac{1}{2}$ cents) at Korat, and $2\frac{1}{2}$ ticals ($1.50) here, only 35 miles distant, with a sandy country intervening, only one hill 200 ft. high to climb, and no serious stream crossing.

"The Governor of Korat, in answer to my inquiries, could do no more than to guess vaguely at the age of the crumbling brick wall surrounding the almost empty city. He could not, or would not, recommend three honest men as night watchmen, and declined to be responsible for the safety of any of our belongings unless we remained in the palace compound. All the business in Korat seems done outside of the walls by a few adventurous Chinamen, who deal in silk, hides, and horns for export and in cotton goods, hardware, opium, tea, etc., for local consumption. There is abundance of useful land in Siam vacant for lack of transport to market for its products."

AN ELEVATED RAILROAD LOCOMOTIVE.

THE accompanying illustration shows a locomotive constructed by the New York Locomotive Works at Rome, N. Y., for the Manhattan Elevated Railroad Company in New York City. This engine is of the Forney type, with Belpaire fire-box, and is one of a number of similar pattern employed in working the elevated railroad lines in New York City. Its general construction and arrangement will readily be seen from the engraving.

The general dimensions of this engine are as follows :

Total weight in working order	44,350 lbs.
Total weight on driving-wheels	29,700 "
Diameter of driving-wheels	3 ft. 6 in.
Diameter of main driving-axle journal	5½ "
Length of main driving-axle journal	6⅝ "
Diameter of truck-wheels	2 " 6 "
Distance between centers of driving-wheels	5 " 0 "
Distance between centers of truck-wheels	4 " 8 "
Total wheel-base of engine	16 " 0 "
Diameter of cylinders	12 "
Stroke of cylinders	16 "
Outside diameter of smallest boiler ring	3 " 6 "

LOCOMOTIVE FOR THE MANHATTAN ELEVATED RAILROAD.

BUILT BY THE NEW YORK LOCOMOTIVE WORKS, ROME, N. Y.

Length of fire-box inside	4 ft. 7 1/16 lbs.
Width of fire-box inside	3 " 7 "
Depth of fire-box, crown-sheet to top of grate	2 " 11¾ "
Number of tubes	154
Outside diameter of tubes	1½ in.
Length of tubes	6 ft. 3¼ "
Grate surface	16.43 sq. ft.
Heating surface, fire-box	55.77 " "
Heating surface, tubes	375.15 " "
Heating surface, total	430.92 " "
Size of steam-ports	8¾×0⅞ in.
Size of exhaust-ports	8¾×1¾ "
Throw of eccentrics	3¼ "
Greatest travel of valve	3¾ "
Outside lap of valve	0⅝ "
Smallest inside diameter of chimney	10½ "
Height, top of rail to top of chimney	12 ft. 1 "
Height, top of rail to center of boiler	5 " 5¾ "
Water capacity of tank	600 galls.

The exhaust-nozzles are single, and are carried up high ; they are bored out 4 in. in diameter. The fuel used is anthracite coal, as on all the engines of this line.

The service in which these locomotives are employed is of a difficult nature, owing to the great number of stops required, and also to the sharpness of the curves, and, on some of the lines, the steepness of the grades. The trains drawn consist usually of four or five cars of the pattern in use on the elevated roads, which is lighter than that of the passenger cars employed on ordinary lines. Under all conditions these engines have done their work well, and appear to be very well adapted to the service.

THE DEVELOPMENT OF ARMOR.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

(*Continued from page 572, Volume LXIII.*)

VI.—STEEL ARMOR.

STEEL has been, almost from the first, the favorite material for armor-plates with the French, and the solid steel plate turned out by Schneider & Company at the Creusot Works is by all odds the superior of anything in the way of steel armor ever yet produced.

In the manufacture of armor at Creusot the steel is cast in cubical ingots of about 75 tons each in weight. These are worked into shape under the 100-ton hammer—seven or eight heatings and hammerings being usually required to reduce the ingots to their final shape. They are carefully annealed after the last working. After being trimmed and otherwise finished for use, they are raised to a high tempering heat, and the face for a short distance tempered in oil, and finally partially reannealed to take out the internal tempering strains, care being taken not to impair the face-hardness. These plates contain about 0.4 per cent. of carbon ; one of them is shown in fig. 4. The 22-in. Schneider plate, 8 × 12 ft., weighs about 45 tons.

In the matter of steel manipulation extensive experiments have been carried on during the past year both in France and Belgium with what is known as the Evrard or lead-tempering process, the invention of a French metallurgist. The right of production under this patent has been purchased by the Chatillon & Commentry Company, one of the largest firms of metal workers of France. Under this patent molten lead is substituted for the oil or water usually employed. The metal to be tempered is immersed in the molten lead, and can be maintained at a uniform temperature throughout its entire mass. As claimed by the inventor, the molten lead, not being decomposed or vaporized by the high temperature of the casting,

absorbs the heat from its surface in a gradual and uniform manner, analogous to the abstraction of heat from the interior of the object. It is further claimed that the largest castings can be tempered in this way without warping and free from cracks, even when containing a considerable amount of carbon.

Soft cast-steel, tempered in this manner, has been experimented with in the fabrication of test armor-plates, and at a series of experiments carried on in Belgium last summer, such good results were obtained that contracts amounting to many millions of dollars are said to have been placed with the Chatillón Company for turret-armor for coast defense. Experiments with lead-tempered steel are soon to be conducted in England, and it is reported that a well-known firm of American steel manufacturers are negotiating for the right to use the Evrard process in the

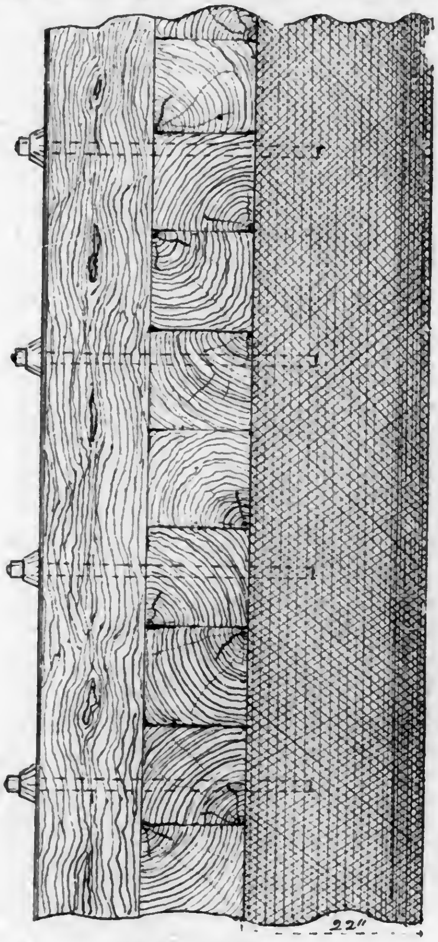


FIG. 4

United States, and that they have prepared a number of armor-plates to be sent to the French Company for tempering. Later, a part of these plates are to be tested at the factory, and the remainder are to be returned to this country for trial.

It can easily be seen that if by this process cast-steel can be successfully tempered, an immense stride has been taken in the development of steel, and for all purposes. Not only will it possess great advantage in the matter of cost over metal rolled or hammered, but it will be possible to use it in shapes that would be difficult to produce by any other method. The inventor claims that the discovery is "applicable to pieces of iron or steel of any degree of softness or hardness, rolled or forged, or simply cast, or of cast-iron, or finally of a mixed or compound nature, resulting from the association of some of the foregoing."

During a greater part of last year a series of experiments were carried on at Portsmouth, England, to test the relative merits of steel and compound armor. Of the 11 plates submitted all were of domestic manufacture, and all but two of steel. Plates of solid steel, cast-steel, unwrought, rolled, solid pressed and compound cast-steel figure in the list. The results of these experiments have been carefully guarded. It appears, however, generally speaking, that English compound are superior to English all-steel plates. There were two steel plates submitted which gave results that deserve mention—the Vicker's solid pressed and the Jessop cast-steel compound plate.

The Vicker's plate was of solid pressed steel, 6½ ft. × 8 ft. × 10½ in., and contained about 0.3 per cent. of carbon. It was attacked with two Palliser chilled and three Holtzer hardened steel 100-lbs. shot from a 6-in rifle at 10 yards' range. The calculated muzzle energy was 2,556 foot-tons. The two Palliser shot went to pieces without inflicting material damage. The first Holtzer penetrated as far as the wood backing, and was driven out again by the elasticity of the metal with force sufficient to send it back against the bulkhead through which the gun was fired. The damage to the target was confined to slight cracks around the hole made by the projectile. The second shot did not penetrate to the backing as far as could be seen, but rebounded in the same way the first had done, causing some additional cracks. The third Holtzer was sent rebounding to the front, like the other two, after making a slight penetration in the wood backing. Of the three steel projectiles, only one was seriously set up. The plate, although somewhat cracked and bulged at the rear, was, for all practical purposes of defense, as good as ever. This trial might be called a victory for both plate and projectile. The wonderful elasticity of the plate was matched by the magnificent quality of the metal of the projectile, which could do its work and hold together under the enormous stress put upon it. A second plate of the same description was tested some months later. Neither plate nor projectiles made quite as good a record as in the first instance.

The Jessop plate of compound cast-steel was, like the Vicker's plate just mentioned, tested on the *Nettle*. The plate was of the same dimensions as the Vicker's plate, and the conditions of the attack were identical in all respects. It consisted of two layers of steel; the outer one, or face of the plate, was made up of 12 separate pieces of very hard cast-steel, aggregating 3 in. in thickness; the other layer was of one solid soft cast-steel plate of 7½ in., giving a total thickness of plate of 10½ in. The advantage claimed for this peculiar construction was that, should a projectile strike one or more of the outer hardened plates, the destructive effect of the blow would be entirely local, and that no cracks would extend beyond the immediate vicinity of the point struck. The results of the trial were considered encouraging, and fully confirmed the claims of the inventor.

Whitworth, who may be called the apostle of steel in England, had been from the first an advocate of the all-steel armor-plate, and in 1887 entered the lists against both Cammel and Brown with a 9-in. plate of peculiar construction. His plate was of untempered steel reinforced by numerous screw-plugs of very hard steel inserted after it was finished. The office of the steel plugs was both to break up the projectiles and also to limit any cracks that might be developed to the space between adjacent plugs. In the experiments that followed this plate proved itself superior to either of its competitors. In another plate, subsequently submitted for trial, Whitworth carried out in another direction his theory of the subdivision of armor with the view of localizing the cracks that are pretty sure to follow the blow of a projectile against hard armor. This plate, of compressed steel, was made up in sections, each section consisting of concentric rings around a circular disk. But Whitworth was no more successful in getting a fair hearing for his armor-plate than he had been in securing a favorable verdict from the English military authorities for his ordnance, although it seems safe to say that had England followed the lead of Whitworth instead of that of Armstrong and the Woolwich people she could to-day lead the world not only in the fabrication of guns, but in armor-plate as well.

The rivalry between the compound and the all-steel plate, which began immediately after the Spezia experiments in 1876, when Schneider won his first victory for steel, still continues. England has been committed to compound armor from the first, while France has been an equally strong advocate for steel. National pride has, no doubt, had much to do in both cases with the choice. Italy

decided in favor of steel, and our own Government has, wisely we think, followed the same example.

In compound armor the office of the hard steel face is to oppose penetration and break up the projectile, while the soft iron backing holds the face up to its work, and prevents the extension of cracks through the plate. On the other hand, by far the larger half of a compound plate is of a material that offers the minimum resistance to a projectile, and a shot, once fairly through the hardened face, will have little difficulty in effecting complete perforation; in addition, the union between the steel and the iron is by no means perfect, while the backing naturally deteriorates under the rolling and reheating to which the plate is subjected.

A steel armor-plate, though possessing less hardness of face than a compound one, is more rigid throughout its mass, and offers a nearly uniform resistance through the entire thickness of plate. Schneider's first armor-plates were little more than steely iron. Subsequently the opposite extreme was reached, and, as shown in the Gavres experiments of 1880, and the Russian experiments of 1882, the opposite extreme was reached, and a plate almost as brittle as cast-iron was produced. The result of these experiments was to give a temporary set-back to the Schneider product, and a corresponding advance in favor of compound armor. In later productions a proper mean seems to have been struck, and the triumph of the steel plate at the Spezia experiments, had in the autumn of 1882, was quite as pronounced as its original victory upon the same ground in 1876, and it might be added that the result of the competitive trials since that date have been to confirm the verdict in favor of steel.

The weakness of a steel armor-plate, or of any hard armor, lies in the quality of brittleness—the inclination to crack, break up, and fall from its backing under the blows of a projectile. The desideratum in this direction seems to be a metal that, while possessing the requisite hardness, shall at the same time have the tenacity to hold together; in other words, one that shall be hard without being brittle. The solution of the difficulty would seem to lie in the direction of a mild steel that can be tempered without losing its tenacity. That this will be attained appears to be no longer doubtful.

VII.—CAST-IRON ARMOR.

The value of cast-iron as a material for armor lies in the fact of its great hardness, and when chilled this becomes so excessive as to absolutely defy any projectile yet produced. But allied to this quality of hardness is the lack of both elasticity and ductility; in other words, it is unyielding and brittle. The same objections that attend this quality in steel apply with much greater force to cast-iron. To be valuable as a material for resisting projectiles it must be used in masses so large as to preclude its employment anywhere except in permanent land fortifications, where weight and size are not important factors; and only in this rôle will it be considered.

Reference has already been made to early experiments with cast-iron, looking to its use in the manufacture of armor. No satisfactory results were obtained until Herr Grüson, a German iron-founder, brought forward his chilled cast-iron armor blocks. These have been pretty thoroughly tested, and so successfully that Grüson armor is now employed in the construction of forts by all the principal powers of continental Europe, France excepted. Herr Grüson began his experiments with chilled cast-iron many years ago, and disputes with Palliser the credit of having first invented the chilled cast-iron projectile. To-day Grüson's chilled cast-iron is the only representative of this variety of armor.

The secret of Grüson's success with cast-iron is said to lie in the superior quality of his pig, in the mixing of the ores, in regulating the chill, and in the great care exercised in the casting. To this may be added the fact that the blocks or plates are cast in chill molds, which gives to the exterior of the casting a very hard surface, while the interior remains relatively soft. The peculiar shape given to the blocks adds greatly to their resisting power, the aim being to present a curved surface to the impact of a projectile. With a plate of this kind no appreciable penetration is possible. If destroyed it must be done by repeated blows delivered near the same spot.

In the manufacture of this armor an exact model of the plate to be cast is made; if of a fort, of each separate part. With the model or models thus obtained ordinary sand molds are prepared, in which are cast the chill-molds for the plates. The melted pig is drawn from the furnaces into a single receiver, and from thence fed directly to the mold, care being taken to prevent the rapid cooling of the unchilled portion of the casting. The ends of each plate are provided with a groove, and into the groove of the two adjacent plates melted zinc may be run, or iron keys inserted, when the battery is set up, thus obviating the use of bolts or any other fastenings whatever.

The general form of the Grüson plates is shown in the accompanying cut (fig. 5). They are made of various

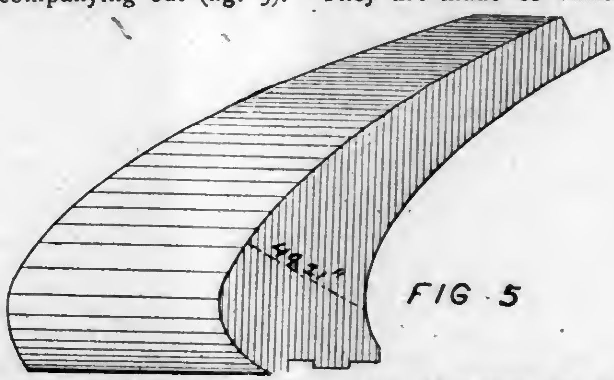


FIG 5

weights and thicknesses. The one pitted against the 100-ton gun at Spezia in July, 1886, and from which trial it came with flying colors, had a thickness of something over 49 in. at its thickest part, and weighed about 87 tons. This plate is a fac-simile of those used in the construction of the two turrets in Spezia harbor, in which are to be mounted the four 119-ton Krupp guns recently delivered to the Italian Government.

The value of any kind of armor rests, of course, upon its ability to keep out hostile shot, and conversely the value of the gun depends upon its being able to get through the armor-plate and inflict injury upon the men and material behind it.

To measure this value in the gun, the standard that has been adopted is the amount of penetration of its projectile into wrought-iron armor. In nearly all reports upon the ballistic qualities of guns will be found a statement as to the thickness of iron its shot can perforate. Knowing the diameter and weight of the shot and its striking velocity, it is not difficult to calculate the amount of penetration of any given shot. Fairbairn's formula is as follows:

$$t=\sqrt{\frac{Wv^2}{2g}\times\frac{1}{\pi D}\times\frac{1}{K}},$$

in which t represents the thickness in inches of plate perforated; W, D, and v the weight, diameter, and striking velocity in foot-seconds of the shot, and K a constant determined by experiment. Roughly estimated, a pointed projectile will penetrate as many times its own diameter into wrought-iron as it has thousand feet of striking velocity. The penetration into steel armor is from 25 to 30 per cent. less than in wrought-iron.

VIII.—WOOD ARMOR.

In addition to the armor proper of a war-ship, it is now proposed to supplement it with a belt of some material that, while offering little additional resistance to a projectile, will prevent the ingress of water following a successful blow delivered at or below the water-line. It is further proposed to apply this protection not only to armor-clads, but to vessels of a lower class unprovided with side-armor as well.

In 1886 some experiments were made in England with a substance called *woodite*—very much like porous india-rubber—which is said to be not only very elastic, but non-inflammable and unaffected by salt water. This material, in the shape of 8-in. cubes, was vulcanized on to a thin iron plate, and fired at with 3 and 6-pounder rapid-fire guns. The report goes on to say that it was difficult to

discover the points of entry, and that the protection against the influx of water was perfect. This substance has been patented in England, and has received the indorsement of some well-known authorities on naval construction. It weighs about 50 lbs. to the cubic foot, and costs £450 per ton. Its excessive cost has led to the production of a substitute which is said to weigh but about one-fifth as much as rubber, and to cost but one-tenth as much, and, while inelastic and slowly inflammable, possesses a very low absorbent power. It is proposed to pack this over the protective deck in small compartments, 18 in. deep amidships and 6 ft. deep at the sides.

The French, for this purpose, have adopted cellulose (compressed cocoanut fiber), which expands under the influence of water and prevents its inflow. This substance is to be confined in coffer-dams, and to form a complete belt near the water-line. The *Dupuy de Lôme* is to have a belt of this character above her protective deck, 1 meter in height. Other French vessels now undergoing construction are to be provided with similar protection.

The Spanish cruiser *Reina Regente* has a complete belt of cellulose extending around the ship, under the inner skin, at about the height of the water-line.

Under the act of Congress of last year authorizing the construction of new war-vessels, it is provided that the two second-class protected cruisers shall have, in addition to the protective deck, above this deck, at the water-line, a coffer-dam running along the ship's side filled with woodite or other cellulose material. The three second-class, partially protected cruisers, are likewise to be provided with coffer-dams 15 in. wide, filled with the same material, to run above the protective deck alongside the fore-and-aft bulkheads, its top to be 4 ft. above the water-line.

(TO BE CONTINUED.)

THE INTERNATIONAL RAILROAD CONGRESS.

(*Continued from page* 550, *Volume LXIII.*)

In the Second Section, questions relating to motive power and rolling stock were considered. The first of these was Question VIII, on Means for Facilitating Passage of Vehicles around curves. The report was made by M. Banderali, Chief Engineer of the Northern Railroad of France.

The Congress decided that it was necessary to take into account both the track and the rolling stock in diminishing as much as possible resistance upon curves of small radius.

Track.—The superelevation of the outer rail on curves, although indispensable, should not be too great, and it is of more importance to have the rails upon curves well secured and accurately gauged; the use of transition curves in passing from the tangent to the curve is recommended, with all possible means of preventing too sudden a change of direction.

Locomotives.—The different methods employed to enable locomotives to pass easily around a curve were considered, including the allowance of longitudinal and transverse play in the journal-boxes; the use of blank tires without flanges on some of the wheels; the use of spherical bearings for the coupling rods and increased coning for the leading wheels, etc. Attention is drawn to the use of different arrangements permitting changes in the position of the axle, such as the radial journal-boxes, the Bissel truck, and especially a leading truck in the place of fixed leading wheels. The use of equalizing levers to secure proper distribution of the weight is also recommended, and finally, for causes of exceptional curvature, the use of double or twin locomotives.

Cars.—For carriages or wagons with two axles only, the use of journal-boxes admitting of considerable play is recommended. For those with three axles, the use of boxes having considerable play for all the axles, and of longitudinal play for the boxes on the center axle. For cars of unusual length, the use of trucks is recommended.

Finally, it is recommended that before the next meeting of the Congress careful experiments be made to show the resistance of cars furnished with various devises mentioned on curves of different roads.

Question IX related to Changes of Gauge and the practicability of transferring cars from one gauge to another. The report was made by M. Blancquaert, Chief Engineer of the Belgium State Railroads.

The conclusions of the Congress were that the difficulties of changing the wheels on passenger equipment were so great that they would not be counterbalanced by the convenience obtained by avoiding the transfer of passengers.

For freight cars, where the freight can be transferred cheaply, the transfer will be less costly than the change of the wheels. Where there is special freight which is difficult to transfer, it is recommended that it be carried on special crates or cars, which can be handled by cranes or other means, and transferred directly from one flat car to another. In special cases it may be possible to provide running gear especially adapted to the change.

This conclusion will seem to us in this country rather behind the times. The principal changes of gauge in Europe are at the Russian and the Spanish frontiers, the gauges adopted by those countries being different from those in use in the rest of Europe. At the Spanish frontier the amount of freight transferred is not great, but at certain points on the Russian frontier there is a great deal of heavy freight, including grain, the transfer of which must be costly.

Question X related to the Application of the Compound Principle to Locomotives. The reporter was M. Parent, Chief Engineer of the French State Railroads.

The conclusions were that, while the use of compound locomotives shows some economy in fuel, on the other hand, there is an increase in the cost of maintenance and of lubrication. It is considered, however, that further trials are desirable, and that the compound locomotive may be found useful in many places, especially where the cost of fuel is high.

Question XI related to the Applications of Electricity, and was divided into three parts: A. Lighting of Trains and Stations; B. Brakes; C. Welding of Metals, especially in repairs of rolling stock. The reporters were M. Sartiaux, Chief of Telegraph Service of the Northern Railroad of France, and M. Weissenbruch, Engineer of the Belgian Ministry of Railroads. The conclusions of the Congress were as follows:

A. Lighting of Trains and Stations.—Considering the progress made in lighting trains by electricity, the experiments already made ought to be continued. As to the lighting of stations, there is no doubt as to the advantages of the application of electricity, the only question being as to cost. It seems probable, however, that, while the first cost of an electric lighting plant may be greater, the cost of maintenance in most cases is less, considering all the advantages.

B. Brakes.—It is considered that no special progress has been made with electric brakes during the past two years, and the question whether they can be generally and practically applied is still undecided.

C. Electric Welding.—Several processes of working and welding metal by electricity have obtained a certain development, but the Congress considered that further trials were necessary, and the question was postponed until the next meeting.

The Second Section, under Question XII, adopted the following list of subjects for consideration for the next meeting of the Congress: Tires; Smoke-stacks for Locomotives; Best Utilization of Rolling Stock; Steam Production; Lubrication of Locomotives. The Congress approved this list and added one more subject, Locomotives for Yard and Station Service.

The Third Section of the Congress had under consideration the questions relating to Management, which were five in number.

Question XIII related to the Dead Weight of Trains, the report being made by M. Lefevre, Assistant Superintendent of Transportation of the Western Railroad of France.

The conclusions of the Congress were that the selection of a type of passenger carriage must depend on the nature of the traffic, and a number of circumstances peculiar to

each line. It is important to reduce the dead weight as much as possible, but in many cases the weight of carriages must be increased in order to give travellers necessary comforts. Wherever possible, however, the rates should be also increased, so that the traveller may pay for the cost of the additional weight. For freight cars no general rules can be established, in consequence of the great variation in kind of traffic and circumstances; but every possible effort should be made to reduce the proportion of dead to paying weight.

Question XIV related to the Organization of Freight Service and of Freight Trains, the reporter being M. Ronneau of the Paris, Lyons & Mediterranean Railroad.

The Congress considered that no general rules can be established under this head, the management of the freight traffic depending entirely upon the nature of the traffic, its amount and many other circumstances. The only general rule seems to be that it is best to hasten the movement of freight as much as possible, in order to secure the best utilization of the rolling stock.

Question XV related to Yard and Station Service, the reporter being M. Pichon of the Midland Railroad of France.

The only conclusion reached under this head was that, while the local circumstances and importance of stations must determine the system adopted, that of switching by gravity appears to be the most economical, wherever circumstances permit its use.

Question XVI related to the Best Arrangements for Passenger Stations where the traffic is large. The reporters were M. Cossman, of the Northern Railroad of France, and M. Goffin, of the Belgian State Railroads.

Here again the Congress declined to establish any general rules, holding that local circumstances must determine the arrangements adopted, but called attention to several large stations recently built in European cities where the arrangements seem worthy of imitation.

Question XVII related to the subjects to be considered for the next meeting. The subject chosen was Station Service, which was divided into two parts: A. The Installation of the Station, including the arrangement of yards, handling of traffic, arrangements for switching, unloading, etc. B. Station Agents and Staff. The Congress approved this question, and directed that these questions should be addressed to all the companies connected with it, and that they be requested to report the fullest particulars possible under this head.

The Fourth Section considered the questions relating to General Order, which were six in number. First of these was Question XVIII, which covered the Relations of Railroads and Navigable Waterways. The reporter was M. Colson, Engineer.

The Congress considered this subject at much length, and while recognizing the fact that in many cases the development of canals and other internal navigation was an advantage to the railroads, held that in other cases the result might be very different. It is claimed that while internal navigation in many cases receives assistance from the State, and is not burdened with taxes on the other hand, the railroads not only had to pay the expenses of management and maintenance and to pay interest on their capital, but are burdened with heavy taxes and with duties relating to postal and military service, which cause a considerable expense. The following is the declaration put forth:

"1. That these inequalities, especially those in relation to taxes, should be suppressed or, at any rate, reduced as much as possible by all measures which can be adopted by the different governments, and which may be compatible with the interest of commerce and industry.

"2. Especially where it can be avoided hereafter, no new waterways should be opened in districts where the railroads can sufficiently serve the traffic."

Question XIX related to the Means of Improving International Relations with regard to the Transportation of Passengers and Baggage. The reporter was M. De Perl, of the Grand Russian Railroad Company.

The Congress recommended a general treaty to cover the subject of the passenger and baggage service, and also expressed the opinion that arrangements should be made to facilitate as much as possible the examination of baggage at frontier custom houses.

Question XX related to Premiums to Employés for Economy in Expenditures and for Increase of Receipts. The reporter was M. Ambrozovics of the Hungarian Railroads. This question was discussed at some length, and, in the opinion of the Congress, presented many difficulties. It was considered that premiums for economy in expenditures—as of expense for fuel, oil, etc., on locomotives—were desirable, as bringing into play the personal interest of the employé in improving the results of working. As to premiums and commissions for increase of business, the case was much more difficult, and the Congress did not approve of the idea of premiums based on increase of gross receipts, on account of the great difficulty of determining exactly the agents causing such an increase. Premiums based on increase in net receipts would be less difficult to establish, but it was considered profitable to adopt here the form of a gratuity or dividend, the amount to be determined by the directors, and the division to be decided upon in the same way. In brief, the general conclusion was that the system of premium was only to be recommended in those cases where they could be based on a specified amount, and not upon any general or indefinite increase.

Question XXI related to Relief or Benefit Arrangements for Employés. The reporter was M. Georges de Laveleye. The answers were divided into numerous heads, and the report is too long to be given here in full. In general, it may be said that the recommendations included:

1. A careful organization of the management of such institutions.

2. The collection of full statistics in relation to age, period of service, conduct in service, promotion, condition of life (whether married or single), mortality in different departments of the service, and many other points in relation to the physical, mental and moral condition of employés.

In relation to relief funds, it was considered very desirable to secure all possible statistics with regard to the nature and amount of the help given, the amount contributed by the employés to the company, and the percentage of wages necessary to maintain such relief bureaus.

Attention was also called to the advantages which had been secured on some roads, especially in Russia, by the establishment of lending banks or bureaus for making loans to employés in cases of necessity, and to arrangements for providing dwellings for employés.

Co-operative societies for purchasing household supplies, provisions, etc., had also been found to work well in many cases.

It is especially considered that the organization of schools for apprentices and for the instruction of candidates for the railroad service is to be desired wherever it is possible.

Question XXII related to the Composition of Passenger Trains, with special reference to the number of classes. The reporter was Mr. Findlay, Manager of the London & Northwestern Railroads.

The conclusions were, in the first place, that in making up express trains it would be well to include third-class carriages, admitting wherever possible this class of travellers to the advantages of the express trains. This can be done without great increase of cost from the fact that in the third-class cars the dead weight per traveller is generally much less than in those provided in the first and second-class passengers. It is especially desirable that this be done in trains running long distances. It is objected to this that the introduction of third-class carriages in fast express trains would so increase the length of those trains that the speed must be reduced; but where the traffic is large, it is worth while to consider whether it would not be best to introduce a class of express trains principally for such travellers, and which would be intermediate between the fast express and the accommodation trains. The decision of this question must depend upon the amount and nature of the traffic. In many cases it may be of advantage to introduce a fourth class, as is done on the German and some other roads, but the decision of this point must depend upon local circumstances.

Question XXIII related to the subjects for the next meet-

Fig. 2.

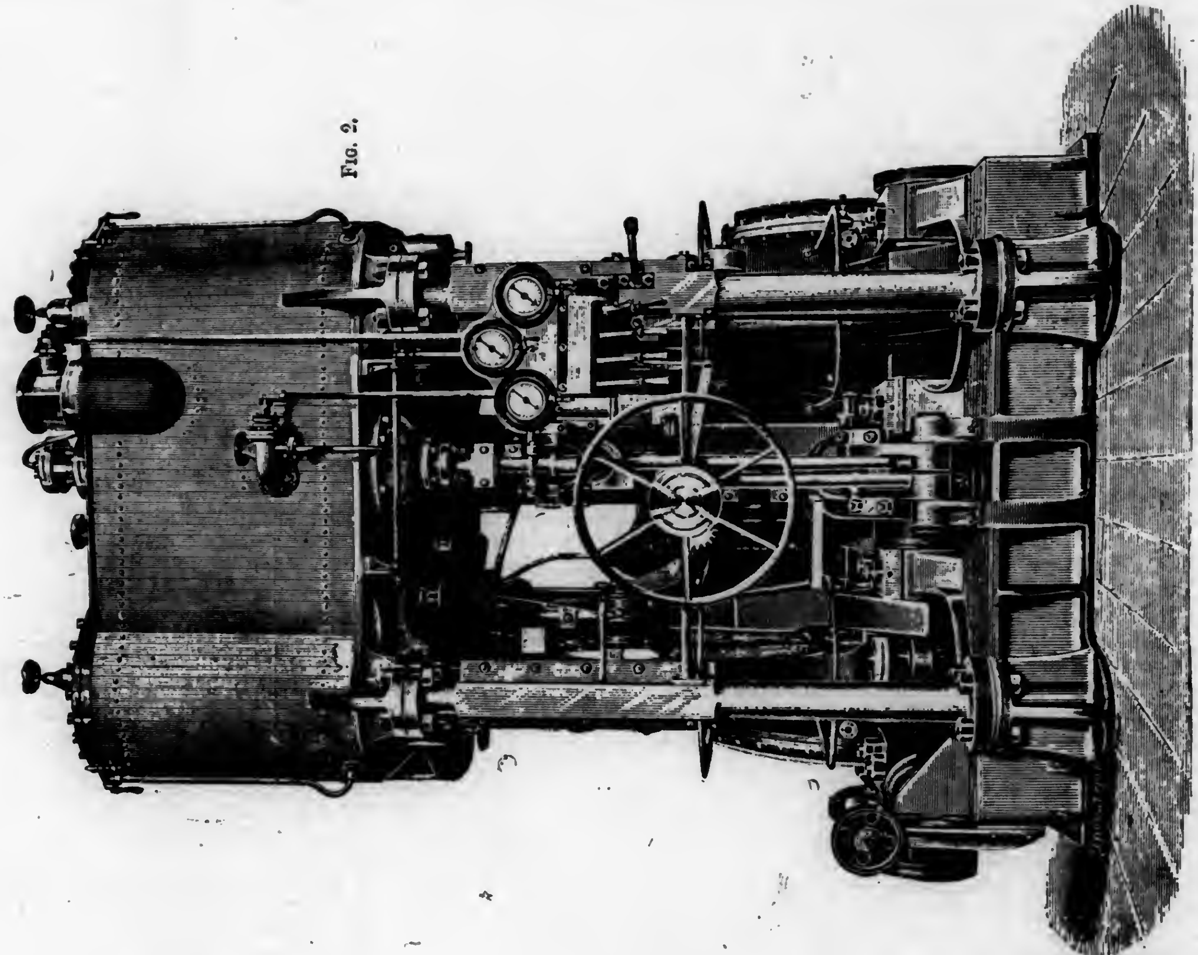
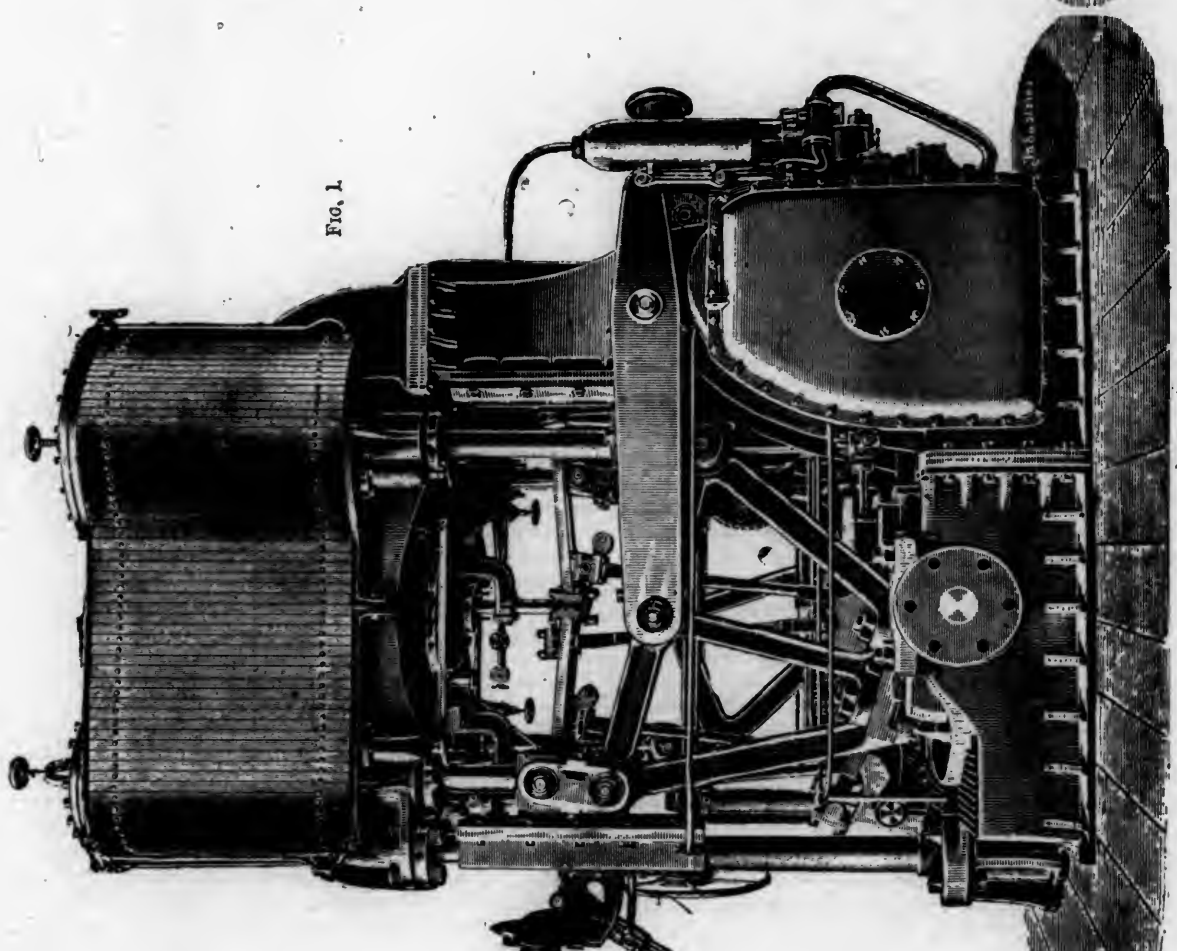


Fig. 1.



QUADRUPLE-EXPANSION MARINE ENGINE.

ing, and those recommended were: Conventional Value of the Different Units of Transportation; Price or Rate per Unit of Transportation, and Coefficient of Management—Classification of Receipts and of Expenses. These were approved by the Congress.

The Fifth Section considered questions relating to the management of secondary or branch railroads. These were four in number. The first, Question XXIV, related to Freight Cars for Secondary Roads. The conclusions reached were that on secondary or light roads the freight cars should be able to carry loads as great as those on the main lines, but that the weight per axle should not exceed that allowed for locomotives.

Question XXV related to Motive Power, and was divided into two sections:

A. Motors other than locomotives—electric, compressed, air, gas, cable, etc.

B. Systems for railroads of heavy grade. The conclusions laid down by the Congress were as follows:

1. The systems of electric accumulators or storage batteries can be used on lines of light grade, but so far have not proved themselves to be sufficient where the trains are heavy or grades are steep.

2. Electric motors with currents conveyed either by overhead or conduit systems can be applied in many places, as in cities, in long tunnels, etc., where the use of locomotives presents inconveniences. Compressed air and hot-water motors can be substituted for locomotives in the same conditions where the runs are not too long.

4. Steam carriages or cars in which the motor is carried in or combined with the car can be used on lines where the traffic is very light, without regard to their length.

5. The rack-rail system can be usefully applied on lines with very heavy grades, and is to be recommended both on account of first cost and cost of operation.

6. The cable system is only applicable for short distances, and is chiefly to be recommended where water-power can be used.

Question XXVI related to the Transfer of Freight between Lines of Different Gauges.

The conclusions were that special installations for transfer trucks, etc., were only warranted where the traffic was large, but in most cases the cost of transferring freight would not be a serious obstacle to the development of secondary lines, which were really needed by the sections they were built to serve.

Question XXVII related to systems of management of secondary roads, whether their operation should be by the company owning them directly, or by contract. This question would, of course, have to be determined entirely by local circumstances.

Question XXVIII related to the Building of Railroads or Steam Tramways upon Public Roads. This was considered advisable in many cases, as, for instance, in connecting neighboring villages, connecting towns with main lines of railroad and similar cases. In all these cases it is considered that the road should conform as nearly as possible to the ordinary tramway or street railroad, using the grooved rail, and arranging the tracks so as to interfere as little as possible with the ordinary traffic of the highway. The only additions to the ordinary tramway would be the necessity of more careful watching of the road in order to prevent accidents.

This concluded the formal proceedings of the Congress, with the exception of the closing session—which was principally devoted to complimentary speeches—and of the banquet and reception tendered the members by the Government and the city of Paris.

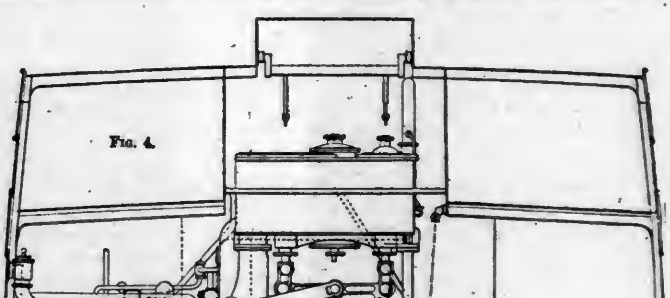
It will be seen that, while a wide range of questions was considered, the really definite conclusions reached were few in number. This was to be expected from the nature of the Congress, as has been remarked before, and it may be said that it accomplished quite as much as might have been expected. Many important subjects are left to be considered at the next meeting, and it is to be hoped that the statistics which are to be collected during the two years before its meeting will be of a nature to throw light upon the disputed points, and to present valuable information for the use of engineers and for railroad managers.

QUADRUPLE-EXPANSION ENGINES.

(From *Industries.*)

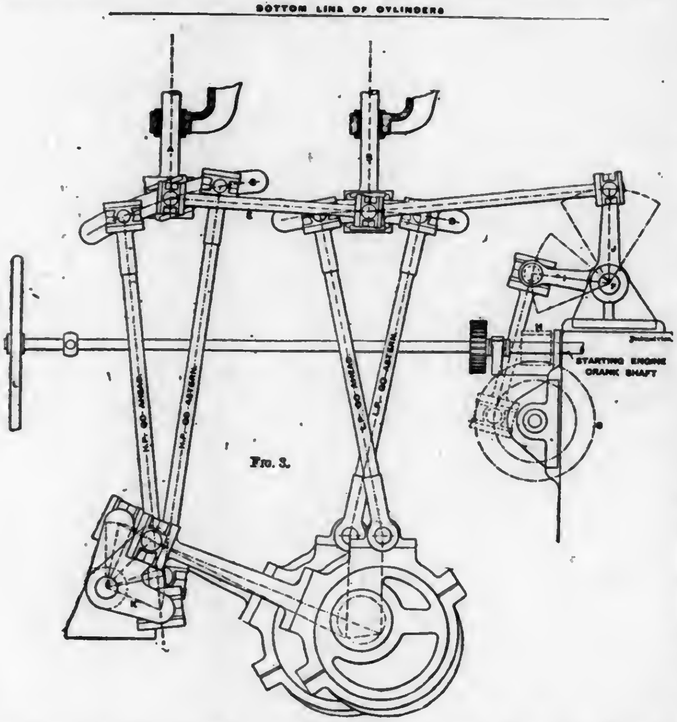
THE accompanying illustrations show a set of quadruple-expansion engines built at the Phœnix Works, Paisley, Scotland, by Messrs. Fleming & Ferguson. Fig. 1 is an end view of the engine; fig. 2, a front view; fig. 3, a detail view of the valve gear; fig. 4 a cross-section of the vessel showing the position of the engines in the ship. This engine has been heretofore illustrated, but the present description is fuller, and the illustrations now given show interesting details of the valve gear, etc., not before given.

As will be seen from figs. 1 and 2, although there are only two cranks, all the four cylinders, respectively 24 in., 30 in., 40 in., and 60 in. in diameter, are placed on the same level and work in pairs. The position of the cylinders is as follows: On the starboard side at the forward end of the engine-room is the high-pressure cylinder; the main steam pipe, 7 in. in diameter, running in a line parallel with the center of the vessel from the boiler to the piston-valve is placed between the high-pressure and intermediate high-pressure cylinder, which is also on the starboard side of the center line. The other two cylinders, with a second piston-valve, are placed on the port side. The cylinders are supported by two cast-iron columns on the condenser and two wrought-iron columns on the bedplate. The cylinders and valve casings have independent covers, permitting of ready access for overhauling. The connecting rods are steel castings of a triangular pattern, each taking a piston rod at the upper angles, while the apex is attached to the crank. To assist the connecting rods when turning the top and bottom centers, as well as to actuate the air, circulating, main bilge, and feed pumps, levers are fixed to both connecting rods. Although the stroke of the cranks is only 36 in., the actual stroke of the pistons is, owing to the oblique action of the connecting rods, 42 in., the levers being proportioned to reduce the stroke of the pumps to 18 in. In large engines, two sets of air and circulating pumps are fitted, but in the *Singapore* there is only one set, worked off the after engine, the air-pump being 21 in. in diameter, the circulating pump, which is double-acting, $11\frac{1}{2}$ in. diameter. The two feed-pumps are $3\frac{1}{2}$ in. diameter, and the two bilge pumps $3\frac{3}{4}$ in. diameter, all with 18 in. stroke. The tails of the forward levers are utilized for working the auxiliary pumps for sanitary



and other purposes. The dimensions of the crank-shaft, piston-rods, etc., are the same in proportion to the size of cylinders as they would be in any other quadruple engine built under the survey of Lloyd's Register, but, owing to the arrangement of triangular connecting rods, there is a better division of power in actuating the crank-shaft as compared with engines of the ordinary type, while greater compactness is secured without sacrificing accessibility. The arrangement of covers to the valves on the upper part of the engine facilitates their removal, while the position of the valve casings between the cylinders economizes space and insures shorter steam passages.

The fore-and-aft space occupied is considerably less than would be required for a triple-expansion engine of 1,600 H. P., which is the power of this engine. Fig. 4 is a cross-section through the engine-room. The boiler, constructed of Siemens-Martin steel, is of the ordinary multitubular type, 14 ft. 6 in. diameter, 18 ft. in length, and having three furnaces at each end. It was tested to 330 lbs. by hydraulic pressure, and works at 165 lbs. per square inch. In a recess on the starboard side of the forward stoke-hole is the auxiliary or donkey boiler, for sup-



plying steam to the steering-gear, winches, etc. ; and a similar recess off the coal bunkers, at the after end of the engine-room, is appropriated to a store-room, oil tanks, and the steam dynamo required for lighting the vessel. On the port side of the engine-room, a large recess is devoted to the usual sea connections, bilge suction boxes, and donkey bilge and feed-pumps, as shown in cross-section in fig. 4. The ballast donkey is placed in the same recess.

Reverting to the main engines, fig. 3 is an illustration of the valve-gear. It is of a simple character, two eccentrics only being required for either ahead or astern gear for all the cylinders.

On the valve spindle *A* there are fixed two piston-valves, one for the high and one for the high intermediate pressure cylinder, both of which work in the same casing. On the valve-spindle *B* there are likewise fixed two piston-valves, one for the intermediate low and one for the low-pressure cylinder. The quadrants *C* and *D* of the respective valve-spindles are connected by drag links *E*. A steam starting engine, fixed on the back of the condenser, gives motion to the worm *H* and worm-wheel *G*, the latter bearing the pin for the connecting-rod of the all-round motion which actuates the quadrants through the bell-crank lever *I J*. The eccentrics are directly in line with the valve-spindle *B*, and motion is conveyed through the bell-crank *K* to the valve-spindle *A*. Reversing is effected either by the steam starting engine or by hand, a hand-wheel *L* being arranged on the outer end of the crank shaft of the starting engine, and should either of the forward cylinders or the forward crank be disabled, the engines can be readily disconnected, and the after engine worked as an ordinary compound.

The fuel consumption, both on the trial trip and in regular work, recorded in vessels fitted with this type of engine is very satisfactory. On the steam trial of the *Singapore*, which was conducted under the supervision of Mr. James Mollison, Chief Engineer Surveyor to Lloyd's Register at Glasgow, the consumption of coal was found to be only 1.121 lbs. per H. P. per hour, the engines running at 80 revolutions and exerting fully 1,600 H. P. The vessel thus attained a mean speed of $12\frac{3}{4}$ knots on the measured mile in Wemyss Bay. The *Singapore* is intended for local trade between Singapore and neighboring ports, and carries 1,500 tons dead-weight on 13 ft. draft of water. Accommodation is also provided for a certain number of passengers.

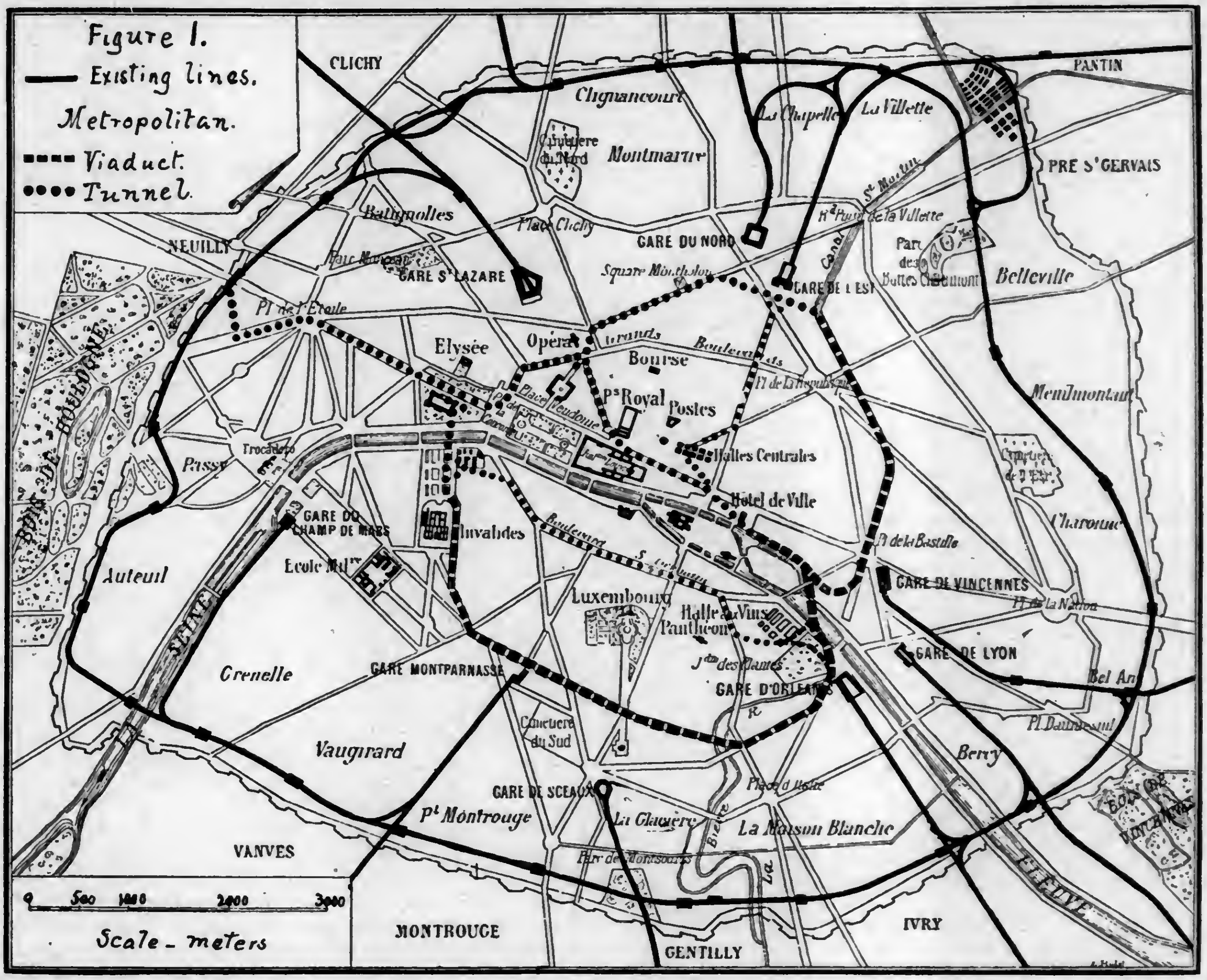
THE PARIS METROPOLITAN RAILROAD.

FOR some time past there has been an active discussion concerning the Metropolitan Line, which is urgently demanded by the necessities of passenger travel in the city of Paris. There is already in existence a Belt Line surrounding the city, connecting all of the railroads which enter it, but that is on the extreme outskirts of the city, and too remote from the center to be of any assistance in solving the problem. This is, as in most other large cities, very much complicated by the questions arising as to cost, right of way, and injury to existing property. A number of plans have been proposed, and the latest (which apparently meets with approval) is that of M. Le Chatelier, a noted engineer, of which we present a general description with some illustrations ; the latter taken from *Le Genie Civil.*

In preparing this plan reference was had to the experience already gained with steam or rapid-transit lines in London, New York, and Berlin. It must be remembered, however, that in Paris the conditions are essentially different from those of the other cities. In New York, owing to the peculiar shape of the city, the lines run in one direction only. In London—as is the case in New York also—special attention has to be paid to a great rush of traffic in certain hours of the day to and from the business quarters of the city, and the main object of the lines is to connect those quarters with the outer districts occupied for residence purposes. In Paris this special movement has practically no existence, and the traffic is much more evenly divided, not only through the different portions of the day, but in the different directions. In Berlin the City Railroad was located and built mainly with a view to military or strategic considerations, the public convenience being entirely secondary. In Paris these conditions are met by the Belt Line, and the Metropolitan Line is intended altogether for public accommodation.

The accompanying map shows a general view of the city, the heavy black lines showing the existing roads, including the Belt Line, and the various lines entering the city, with the location of their stations. The dotted lines show the proposed Metropolitan Road, which may be said roughly to consist of an irregular circle, with three cross lines and an arm or spur connecting with the outer Belt Road. Of the Metropolitan Road about one-half, in the southwestern part of the city, will be a viaduct or elevated road, and the remaining half, in the northwestern part of the city, will be generally in tunnel. These lines, it is thought, will provide for the circulation of traffic in both directions from east to west and from north to south. The lines have been so located as to reduce as far as possible the cost for land and right of way, and to use wherever practicable the public streets, without interfering with the ordinary traffic upon them. Other branches may be added to this system hereafter, as the needs of the city may require. Under this plan, the total length of the lines to be constructed is 23.153 km. (14.387 miles), of which 11.610 km. (7.214 miles), or a little more than one-half, will be above ground, and the remainder in tunnel.

Of the total length of line, 30 per cent. will be level ; 41 per cent. with grades less than 1 per cent. ; 15 per cent. will have grades between 1 and 2 per cent., and the remainder, or 14 per cent., of the total length, will have grades between 2 and 2.5 per cent. Where stations are located upon a grade, the maximum grade passing the station will be in all cases reduced to 0.5 per cent. Again, of the total length of the line, 70 per cent. will be tangent ; 5 per cent. will be in curves of over 200 m. (656 ft.) radius ; 5 per cent. in curves of 200 m., and 20 per cent. in curves of 150 m. (492 ft.) radius. The number of stations provided for is 27, the average distance between them being 857 m. (2,811 ft.), while the shortest interval between two



adjoining stations is 425 m. (1,394 ft.). It would seem, with our New York experience, that the number of stations is rather small, and the interval between them somewhat greater than it should be to accommodate properly the travel.

Fig. 1 is a general map, showing the principal points in the city, and the lines which are to be constructed.

Fig. 2.

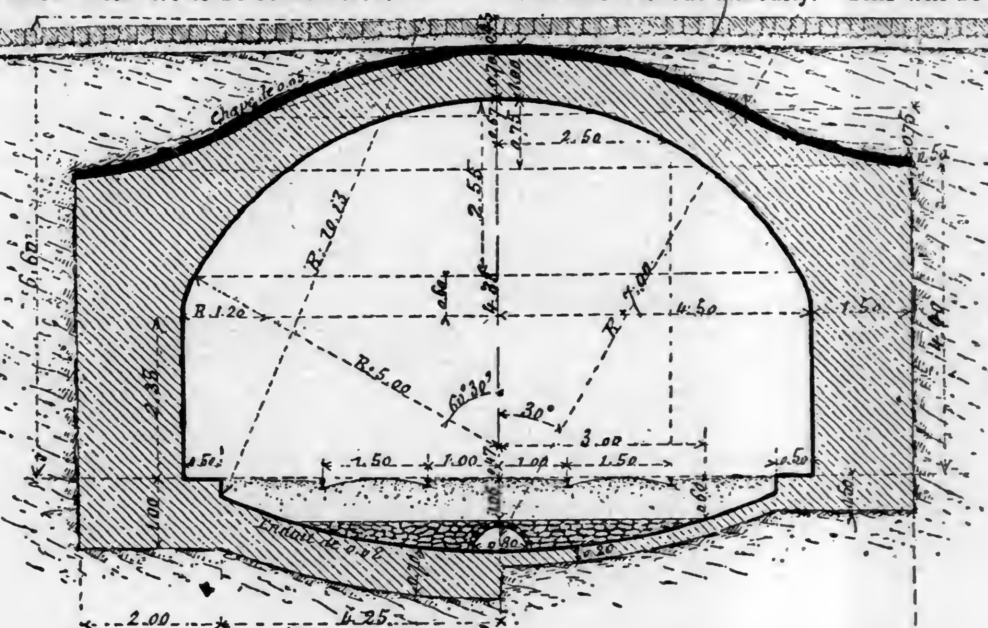
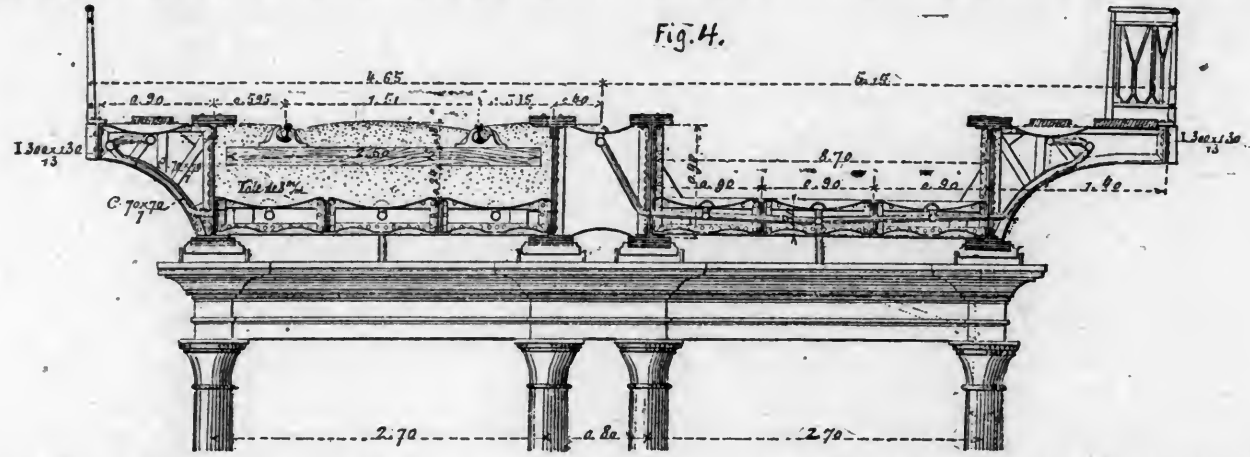


Fig. 3.

The construction of the underground section will be somewhat difficult in consequence of the necessity of avoiding the sewers and other underground conduits, which exist in great number. Especially is this the case where the road must cross the great collecting sewers which run on either side of the Seine. The solution adopted is to divert the sewers from their present line wherever they interfere with the railroad, and to build a new sewer until a point is reached where the crossing can be made without difficulty. This will be the most difficult part of the work, as the construction of the tunnel itself will nowhere present any great difficulties, and it will not be at any point very far below the surface.

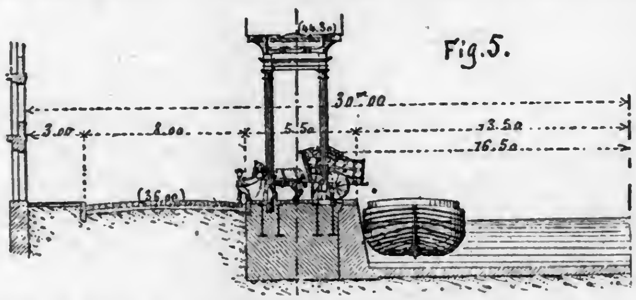
The plan adopted for the road may be divided into three separate types: The underground, the viaduct, and the transit from tunnel to viaduct. In the accompanying illustrations, figs. 2 and 3 show the section adopted for the tunnel; fig. 2 being a half section showing the masonry,

Fig. 4.



etc., in wet or damp ground, and fig. 3 a half section showing the lighter masonry required in dry ground. The tunnel, as will be seen, will have an arched roof, and the bottom will also be arched, giving room for drains, foundation, and the ballast for the tracks. The total height, from the level of the rail to the hightest point of the tunnel, will be 5.47 m. (17.94 ft.), and the total width

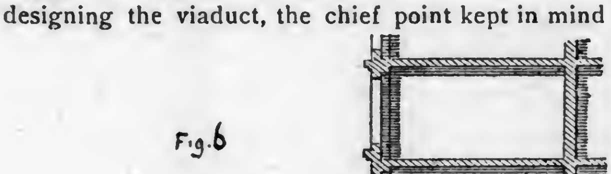
Fig. 5.



10 m. (32.8 ft.). The tracks will be double and of the normal gauge. In general the tunnel could be built by making an open cut, constructing the masonry, then filling up over the masonry and restoring the street pavement. Actual tunneling operations will be needed only in a very few places.

In designing the viaduct, the chief point kept in mind

Fig. 6



has been that every foot of the surface is valuable, and that the supports must be of such a nature as to occupy the least possible space. The general plan adopted for this viaduct is shown in fig. 4. It consists of four girders placed in pairs, each pair carrying one of the tracks; the dimensions are shown on the drawing, in meters.

In order to reduce the noise as much as possible, it is proposed to make the roadway as shown in fig. 4—that is, to carry it on cross-girders supporting a sheet-iron floor, forming with the main girders a trough, which will be filled with ballast, in which the ties will be embedded. As a general rule, the distance between the pillars will be 15 m. (49.20 ft.); this, of course, will have to be varied at points, owing to local circumstances.

Fig. 5 represents a special form of viaduct adopted to meet the case where the road will run along the banks of the St. Martin Canal, and where each track will have to be carried on an independent viaduct. The general construction does not differ very materially from that shown in fig. 4.

The transit from tunnel to viaduct does not present any particular features of difficulty from an engineering point of view. Where the tunnel ceases the road will run for a short distance in an open trench, which will, of course, be carefully walled up, and the depth of which will gradually diminish until the track reaches the surface of the ground. From this point a fill supported by retaining walls on either side will be used until a height of 4 m. (13.12 ft.) is reached, when the metallic viaduct will begin. At some points masonry arches may be substituted for the fill and retaining walls.

The stations, as there is no baggage or freight traffic to be provided for, present a comparatively simple problem. They will consist in general simply of platforms, from which access can be had to the cars, and of steps by which the platforms can be reached from the street. As the interval between trains will usually be short, little or no waiting-room accommodation is needed. In some cases

Fig. 7.

there will be a central platform, which will serve for both tracks, but in the majority of the stations there will be a separate platform for each track, and the tracks will be kept at the regular distance apart. Figs. 6 and 7 show half sections of the stations where the road is underground, fig. 6 showing a staircase running directly from the side-

walk, while in fig. 7 the entrance is in the building at the side of the street, the stairs being in the building or underneath the sidewalk. The latter type is preferred, as it will not in any way interfere with the traffic of the street. Where stations are placed in this way for the underground road, it is considered better to change somewhat the construction of the road ; and, instead of widening the tunnel, to make an open cutting and carry the street over it upon iron girders. This will be done, because the span, including the platform and space for access, would be too great for a masonry arch, except in one or two places where the road is some 30 ft. below the street level.

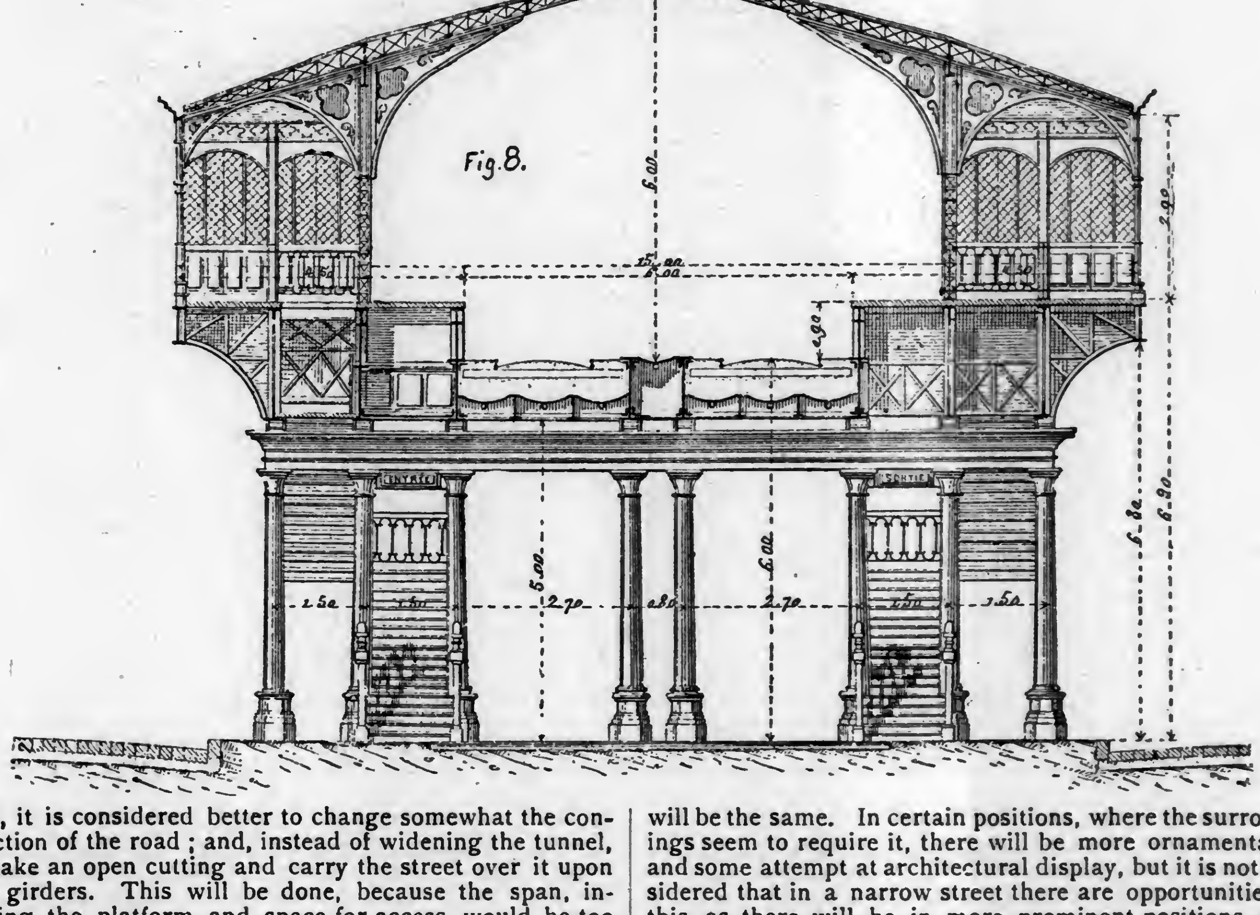


Fig. 8.

Fig. 8 shows a cross-section of a station of the type which it is proposed to use generally where the road is carried on a viaduct. In this case it will be seen that the tracks continue at the normal distance, and the only change made is in lengthening the cross-girders on which the structure is carried, and putting under them additional columns to support the stations. The stations will be constructed almost entirely of iron. Separate platforms are provided, one on each side of the road, and separate staircases. In both the subterranean and the overhead stations the ticket offices will be placed on one of the landings of the staircase. It is not proposed to make all the viaduct stations uniform, although their general plan will be the same. In certain positions, where the surroundings seem to require it, there will be more ornamentation and some attempt at architectural display, but it is not considered that in a narrow street there are opportunities for this, as there will be in more prominent positions, as in the Rue de Rivoli or the Avenue de l'Opera. Fig. 9 shows a plan adopted for a station in an exceptional position. This station is to be placed at a point where the road runs alongside of the St. Martin Canal. Here, as will be seen, the two tracks are separated, and a platform placed between them. The whole structure is carried by arched girders, resting on abutments on either side, spanning the canal and the adjoining quay. At either side of the station, adjoining the canal, the tracks are separated one on each side of the canal, carried on rows of pillars,

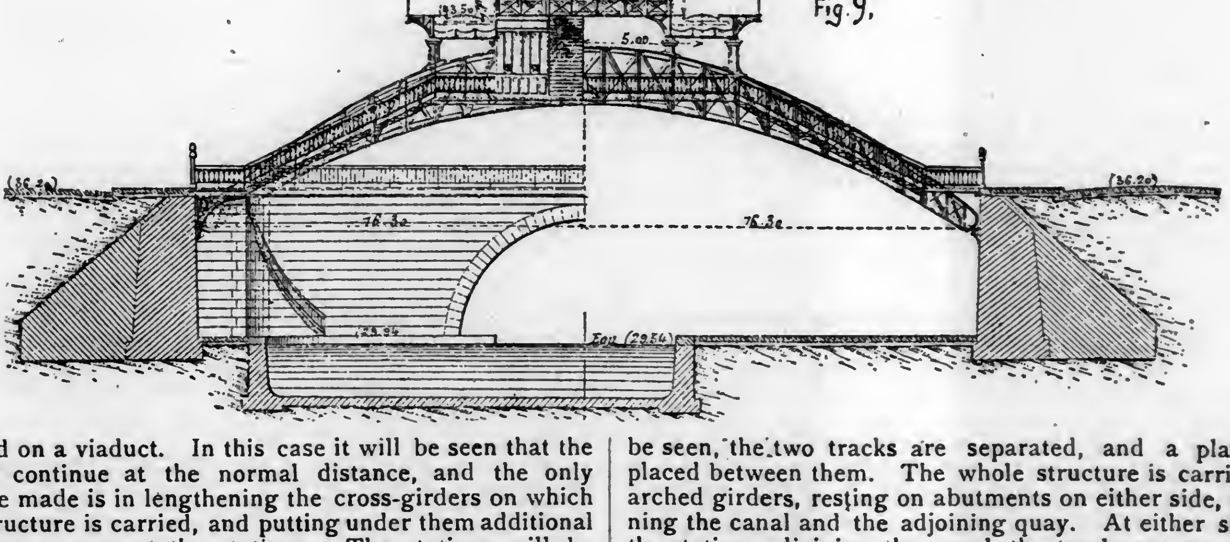
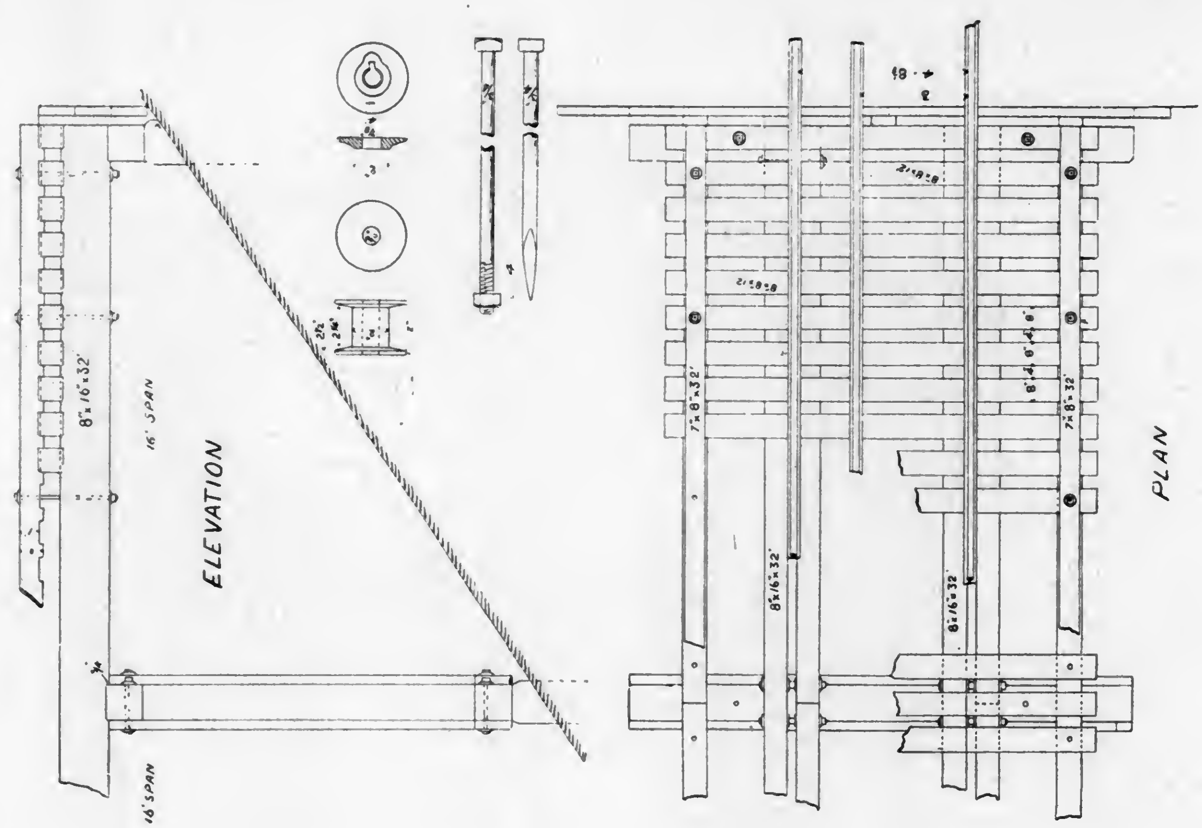


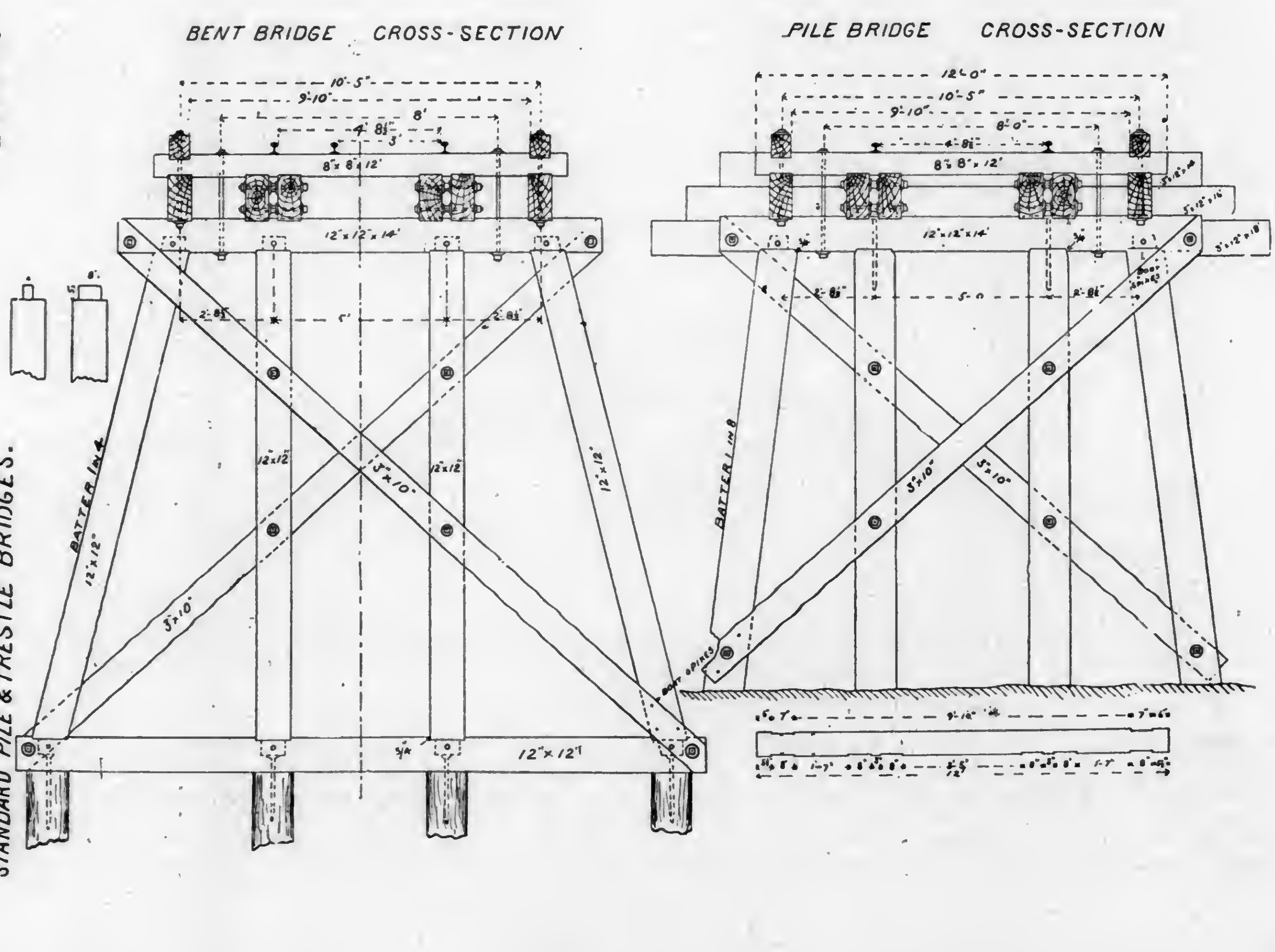
Fig. 9.

PLATE 69



DENVER & RIO GRANDE RY.
STANDARD PILE & TRESTLE BRIDGES

PLATE 68



DENVER & RIO GRANDE RY.
STANDARD PILE & TRESTLE BRIDGES.

as shown in fig. 5. As before noted, however, the system of separate platforms is considered preferable, and a single platform between the tracks will be adopted only in exceptional cases, as in that shown in fig. 9. In this case the stairways giving access to the platform are carried by the cross-girders which support the station. In general the stations will have platforms 4.50 m. (14.76 ft.) in width, and raised 1 m. (3.28 ft.) above the level of the track. Their length is not stated.

An important question where the road is underground is that of ventilation. It has been carefully considered by the engineers and a plan proposed for artificial ventilation, the foul air to be pumped out by engines placed at proper intervals.

The total estimated expense of the construction of the road is $28,000,000, or about $2,000,000 per mile. This includes only a small sum for purchase of private property, as most of the road will be built upon public streets or other city property. The estimate seems somewhat low, and will probably be increased on more careful examination.

The trains will be run by locomotives, but the type of locomotive and of car to be adopted has not yet been decided upon, and is not included in the plan under consideration.

It may be interesting to note that the engineers have submitted a table estimating the number of trains which will be required on different sections of the road. Between the Opera and the Place de la Bastile, by way of the northern circuit, from 8 to 20 trains an hour, according to the time of day, will be needed; between the same points, by the cross-line passing the Hotel de Ville, from 8 to 16 trains per hour; on the southern half of the circuit from 4 to 12 trains an hour, and on the southern cross-line from 4 to 6 trains an hour. It is not stated what number of passengers the trains are expected to carry, but to those who are accustomed to the requirements of traffic in New York or in London, this seems rather a small number of trains.

This plan, it is hoped, will present a solution of the problem which has caused the authorities of Paris so much trouble. To judge from the objections which have been raised to all the preceding ones, however, it seems doubful whether even the eminent authority of M. Le Chatelier will be sufficient to secure its adoption without some modification.

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C. E.

(*Continued from page* 566, *Volume LXIII.*)

CHAPTER XIX.

DETAILS OF TRESTLE CONSTRUCTION.

The general design of all the standard wooden trestles, as shown by the accompanying plates, exhibits a great similarity, the differences in them being due more to local circumstances than to any radical differences in the ideas of the various designers.

With regard, however, to the methods used in carrying out the details of these designs, much difference of opinion prevails. There are two points upon which very few engineers agree:

1. The best method of holding together the joints.
2. The best design for the floor system, as regards safety and economy.

In what follows we wish merely to call attention to some of the different methods used in working out the details of these two points, together with some of the advantages and disadvantages connected with the use of each.

With regard to the details of the joints, the following methods are used, the generality of their use being about in the order given: Mortise and tenon; dowels; drift bolts; bent metal plates or sockets.

The mortise and tenon joint, an example of which is shown in the details of all the standard trestles, is the one in most general use. Its use, in fact, may be called universal, and this notwithstanding the many obvious faults it has. These faults are as follows: First, the cost of construction.

Mortise and tenon joints necessitate a great deal of high-priced carpenter work. In order to meet the requirements all the work must be done with accuracy, and every surface brought to an even and exact bearing. This requires a great expenditure of both time and money, and of course the question is whether the result obtained is an equivalent. No matter how much care is taken with the work, the joints are never water-tight, and thus offer receptacles for the retention of a certain amount of moisture, which hastens decay in a very perceptible manner. All timbers framed together and exposed in such a manner as trestles, bridges, etc., decay at the joints long before any signs are visible at other points.

This decay at the joints renders it necessary to renew the timbers, and as all the stick is perfectly sound with the exception of the mortise and tenon, much good timber is rendered useless. Much of the timber, of course, can be cut down and used over again in some smaller structure, but it is at a cost that nearly counterbalances the gain.

Another disadvantage connected with the mortise and tenon joint is the fact that that portion of the wood utilized to withstand the superimposed weight is the poorest part of the timber, the outside of both timbers only bearing all the strain, while the heart of the timber does nothing. This is the result when only a single mortise and tenon are used. To some extent it is remedied by making two tenons, leaving a bearing surface between them, or, when the timber is sufficiently large, staggering the tenons. Either of these methods gives only a partial solution of the difficulty, and the great extra expense incurred in carrying them out more than counterbalances any gain. The effort is often made to cut the tenon and mortise with such accuracy that the end of the tenon will come to a bearing in the bottom of the mortise, thus utilizing this additional bearing surface. In order, however, to accomplish this object, such a superior class of workmanship is called for that the cost would be all out of proportion to the gain. When ordinary carpenters are employed, all idea of making use of this bearing surface should at once be abandoned, because, owing to the too slovenly manner in which the work is done, if any attempt is made to bring the tenon to a bearing in the mortise the result will be one of two things:

Either the tenon, being slightly too long, will carry all the weight and in a very short time split the cap or sill if the weight is sufficient, or else the tenon will be too short and all the bearing come on the shoulders, as usual, and the extra expense incurred in attempting what has not been accomplished will have been just so much waste.

There is another point also that renders it practically impossible ever to bring the end of the tenon and the shoulder of the joint to an uniform bearing, and it is the fact that the timber used is never thoroughly seasoned, and a certain amount of shrinkage takes place subsequently. This shrinkage occurs always across the grain of the wood to a greater extent than in the direction of the fibers, and therefore, from this shrinking, the depth of the mortise is decreased, while the length of the tenon remains practically the same. From this fact it will be seen that unless, when first framed, the tenon is made shorter than the depth of the mortise, in a very short time all the strain will be thrown upon the end of the tenon, the shoulders of the joint having shrunk away from each other.

The best rule to be followed in designing a mortise and tenon joint is to remember that the tenon must serve simply to hold the two pieces in place, and not to bear any of the strain. All of the strain must be borne by the shoulders, and when the two timbers do not come together at right angles, as in the case of the joints between the batter, posts and the caps and sills, the resulting horizontal thrust must be taken up, not by the tenon, but by cutting down the sides of the mortise until they are at right angles to

PLATE 71

St. J. & I. R.R

FRAMED BENTS
17 to 19 FEET HIGH

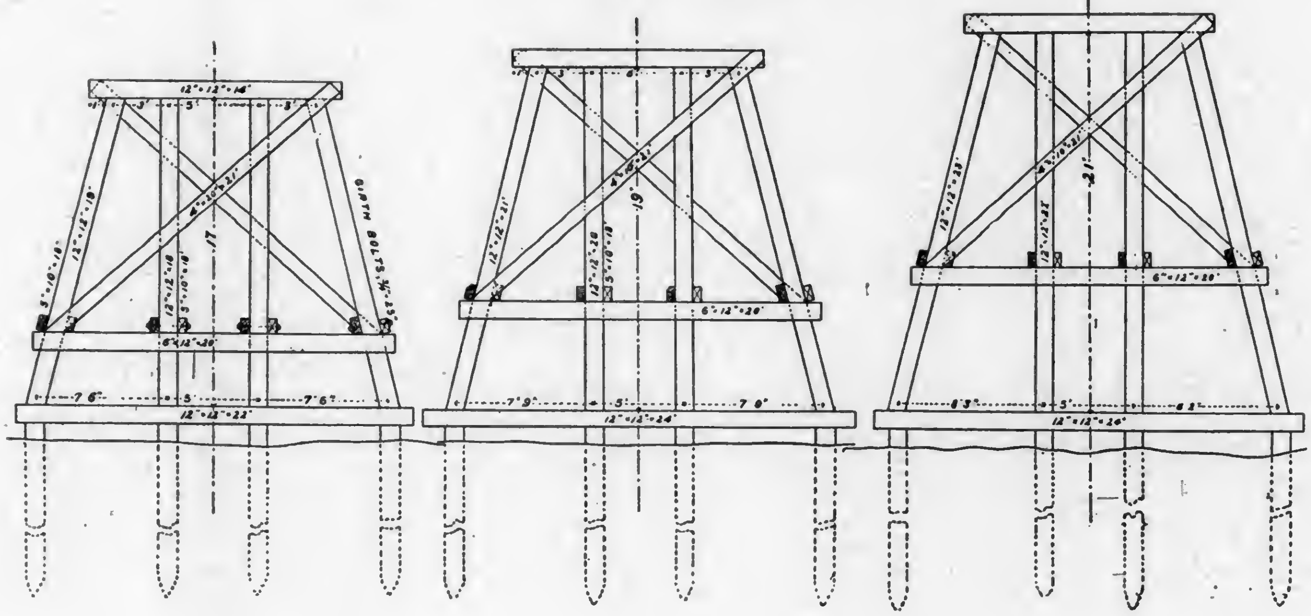


PLATE 70½

St J & I R R
FRAMED BENTS
13 and 15 FEET HIGH

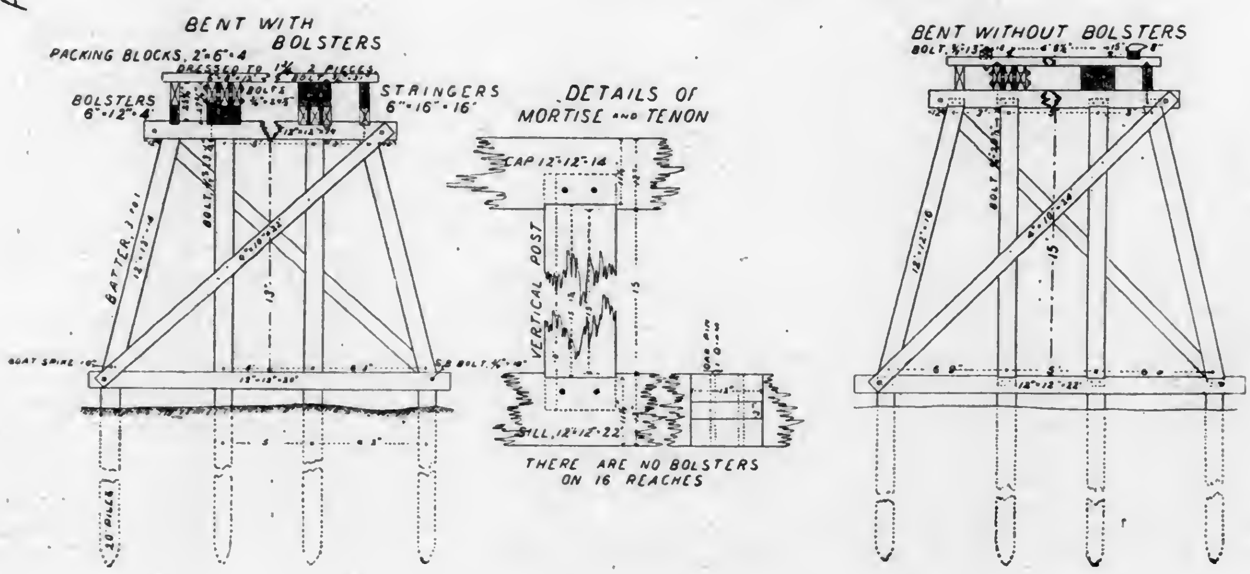


PLATE 72

S^T J & I R R
FRAMED BENTS
23 TO 27 FEET HIGH

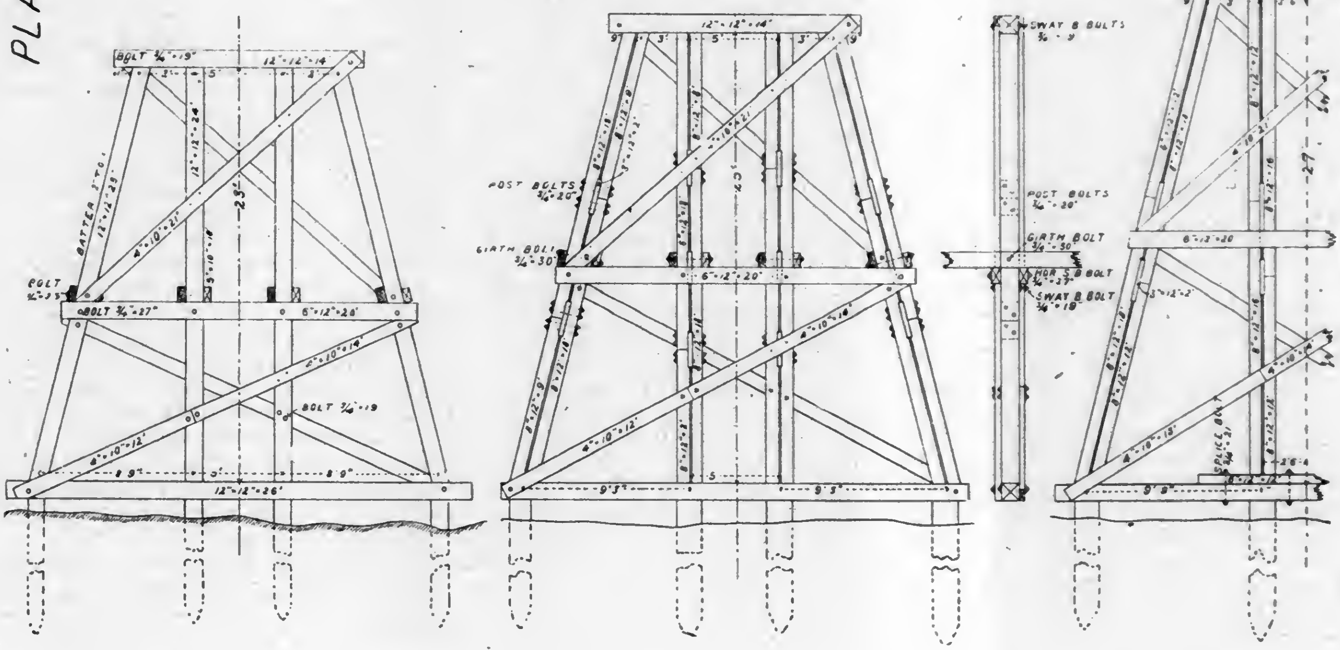
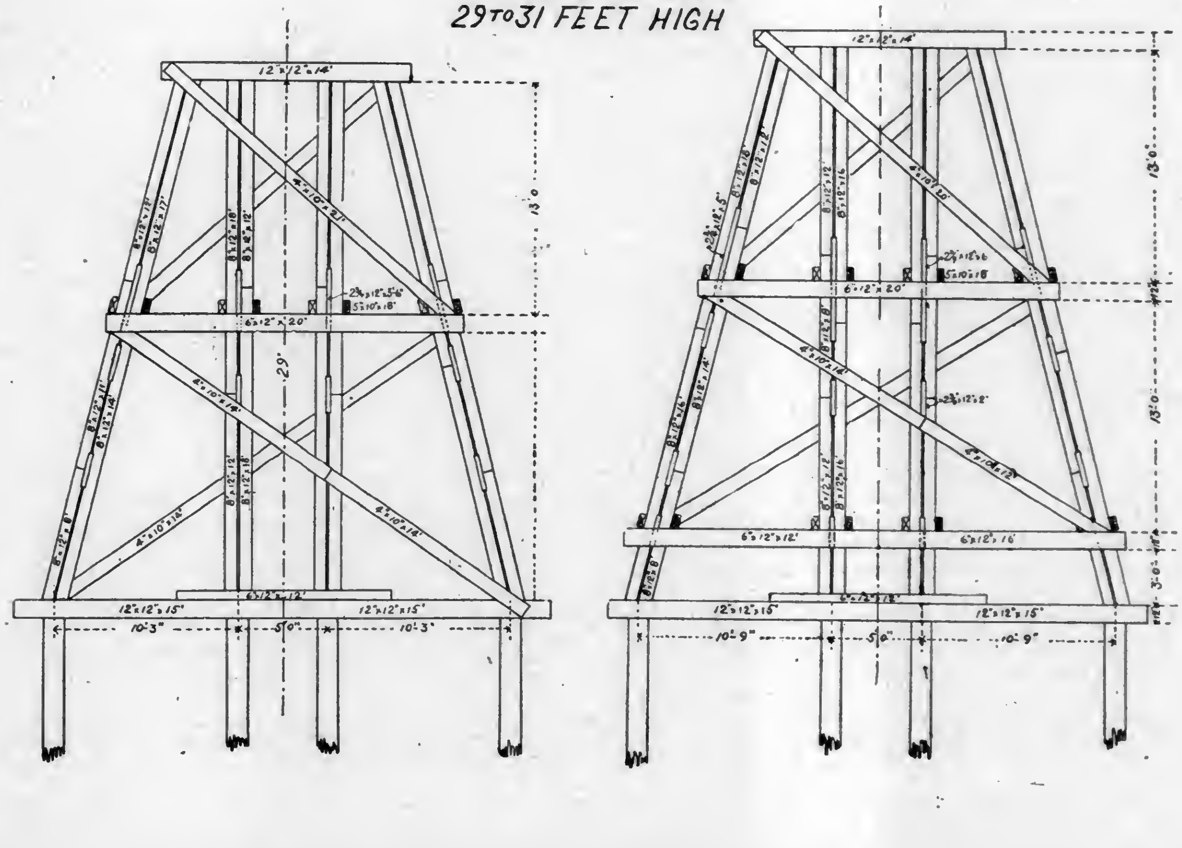


PLATE 73

S^T. J. & I. R.R.
FRAMED BENTS
29 TO 31 FEET HIGH



the line of thrust. The tenon should be made as small as possible, and thus give as large a bearing surface to the shoulders as possible.

Notwithstanding all of these defects inherent in the mortise and tenon joint, it is the form in general use, and undoubtedly will continue such as long as wooden trestles are used.

The advantage connected with its use is a maximum of rigidity and stability to the structure. It is probably as great an example as we have of engineering conservatism. It has always been used in railroad work, and has given uniformly good results, omitting the question of first cost and repairs. The weight of authority is in its favor, and it is always easier to copy ordinary work than to branch off and design and execute really good work.

Probably one reason why engineers have not put more time and study upon this question of trestle joints and details is the fact that wooden structures are considered as being simply temporary, to be at some early date replaced by earthwork or metal, and that thus they are not deserving of that amount of attention that would be required to eradicate many of their great defects.

One method of obviating many of the inherent defects of the mortise and tenon joint is by the use of double caps, sills, posts, etc.—that is, in place of using one timber 12 in. × 12 in., to use two timbers each 6 in. × 12 in. These timbers can be halved or quartered into each other and bolted together at very slight expense. Being only one-half the size, they can be handled with greater ease and rapidity, and bearing surfaces can be obtained not only of equal or greater area than by the ordinary mortise and tenon joint, but this bearing surface can be obtained upon the best portions of the wood, and thus the real value of the wood utilized to a much greater extent. Another great advantage resulting from the use of double timbers throughout is the great ease with which any one piece can be renewed without disturbing the remainder of the structure, and only that piece removed that, from decay or any other cause, requires renewal.

There is no method of construction where the ease and economy of renewal can be rendered so great as in this. It possesses all the advantages that can be claimed for the ordinary mortise and tenon joint, while the disadvantages are reduced to a minimum. The quality of timber used is, for the same price, much superior, and the expense of handling it much less.

The second method of holding the trestle joints together is by means of dowels. These dowels are iron pins cut square at both ends, from 4 in. to 2 ft. in length, and from 1 in. to 2 in. in diameter. Holes are bored for them in the ends of the posts, into which they are driven about one-half their length; corresponding holes are made in the cross-timbers, and everything is firmly driven together. The holes should be of slightly less diameter than the dowels, so that they will fit so closely as to prevent any water from entering. The dowels and the whole joint should be thoroughly painted or covered with some preparation of coal tar before they are put together, and in this way the joint can be made practically water-tight, and an early decay of the timber at the joints prevented. This is one of the advantages the dowel has over the mortise and tenon joint, as it is impossible, with the class of timber used in trestles, to make a mortise and tenon joint tight for any length of time.

The dowel, however, does not make as rigid a joint as the mortise and tenon, and some difficulty is experienced in erecting large bents put together in this manner. But although the dowel joints are undoubtedly lacking in that rigidity that permits a bent framed with mortise and tenon pinned together to be raised as one piece, still, after the bent is in place and the proper diagonal and longitudinal braces nailed on, there is no practical deficiency in rigidity. The expense and time necessary to frame with dowels is much less than with mortise and tenon, the only thing necessary being to bring the contiguous surfaces to an even bearing and to bore the holes for the dowels. In timbers of a given size much less of the bearing surface is wasted by the use of the dowel than by use of the tenon.

The great disadvantage connected with the use of the dowel is the difficulty in making repairs and renewals. The dowels being of iron necessitates the taking down of the greater part of the bent in order to renew any one piece. In the mortise and tenon, the tenon can be cut off with a saw and the piece removed with comparatively little trouble, although with nothing like the ease and facility that is possible when split or double timbers are used.

The third method used is by means of drift-bolts. These bolts are usually of round iron ¾ in. in diameter, pointed at one end and of a length depending upon the dimensions of the timber used. Usually holes of a slightly less diameter are bored for them, and then they are driven into place.

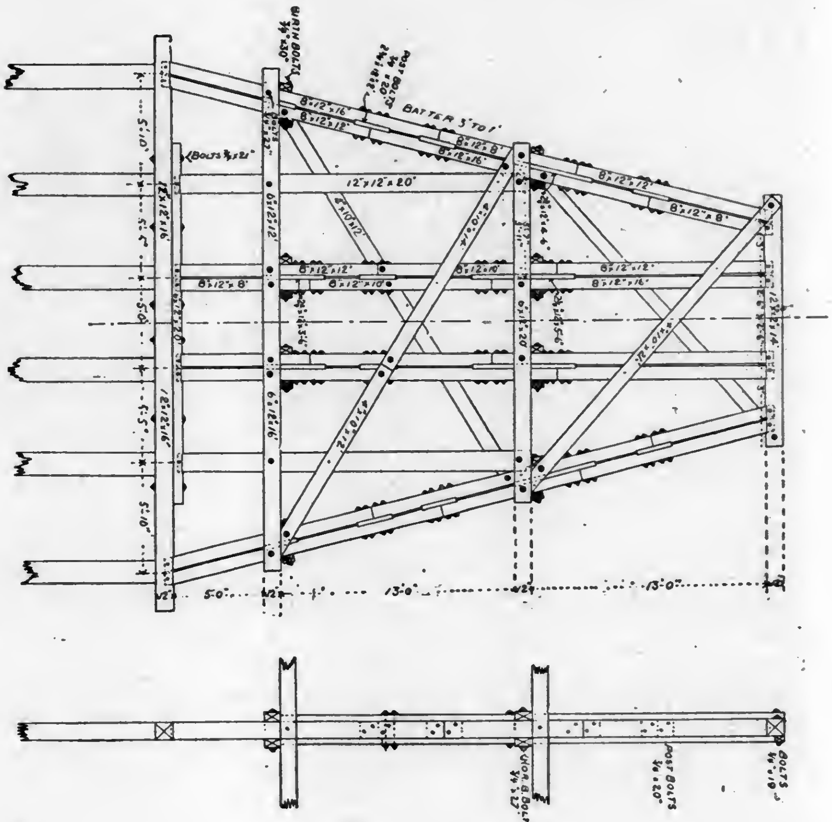
The difference between a drift-bolt and a dowel is as follows: The dowel is usually of much greater diameter and much shorter than the drift-bolt, although this is not a necessity. The whole difference comes in the manner in which they do their work. The dowel simply takes the place of the wooden tenon and does its work in the same manner—that is, it simply holds the timbers in place and prevents any sidewise movement; but neither the mortise and tenon nor the dowel are expected to exert any strength in a line parallel to their longitudinal axis. The timbers are held together in that direction by means of their own weight. In all forms of mortise and tenon joint, however, the above does not hold true, as the tenon is often held to its place by a wooden pin driven through it at right angles to its axis. This, however, is never done with a dowel. The drift-bolt, indeed, acts exactly as a nail does. It not only prevents any sidewise movement in the timbers, but prevents the contiguous faces from drawing apart by the friction of the wood upon its sides. In every way it acts in a manner exactly similar to a nail.

Drift-bolts are the simplest and in construction the least expensive of any of the various types of fastenings used. Nothing is required but to bring the contiguous faces to an even bearing and bolt them together. If proper care is taken and sufficient paint or coal tar used the joint is water-tight and will outlast any other form, but it will not last forever, and is certain to yield to decay before the main part of the timber. Even if this was not the case, still there would come a time when there was a necessity for renewal, and when this time arrives the great disadvantages of the drift-bolt are brought out. There is no practical means of extracting them, and the difficulty of renewing any one piece of a bent is so great that usually renewal is delayed until, in the opinion of the bridge foreman, the whole bent can be economically renewed. As no two pieces of timber are affected to the same degree by decay in the same time, the result is that either the bent is left standing until it becomes a source of positive danger, which is usually the case, or else some good timber is wasted. The use of drift-bolts, however, is very common, and in all temporary work is perfectly allowable. In no other way can the same amount of rigidity be obtained at so slight a cost.

There have been various forms of clamp used at different times for fastening caps and sills to the posts, these clamps being placed upon the sides of the timbers and held in place by bolts with heads and nuts. The difficulty, however, has always been to so design and fasten the clamps as to make the joint rigid, and their use has never been attended with much success.

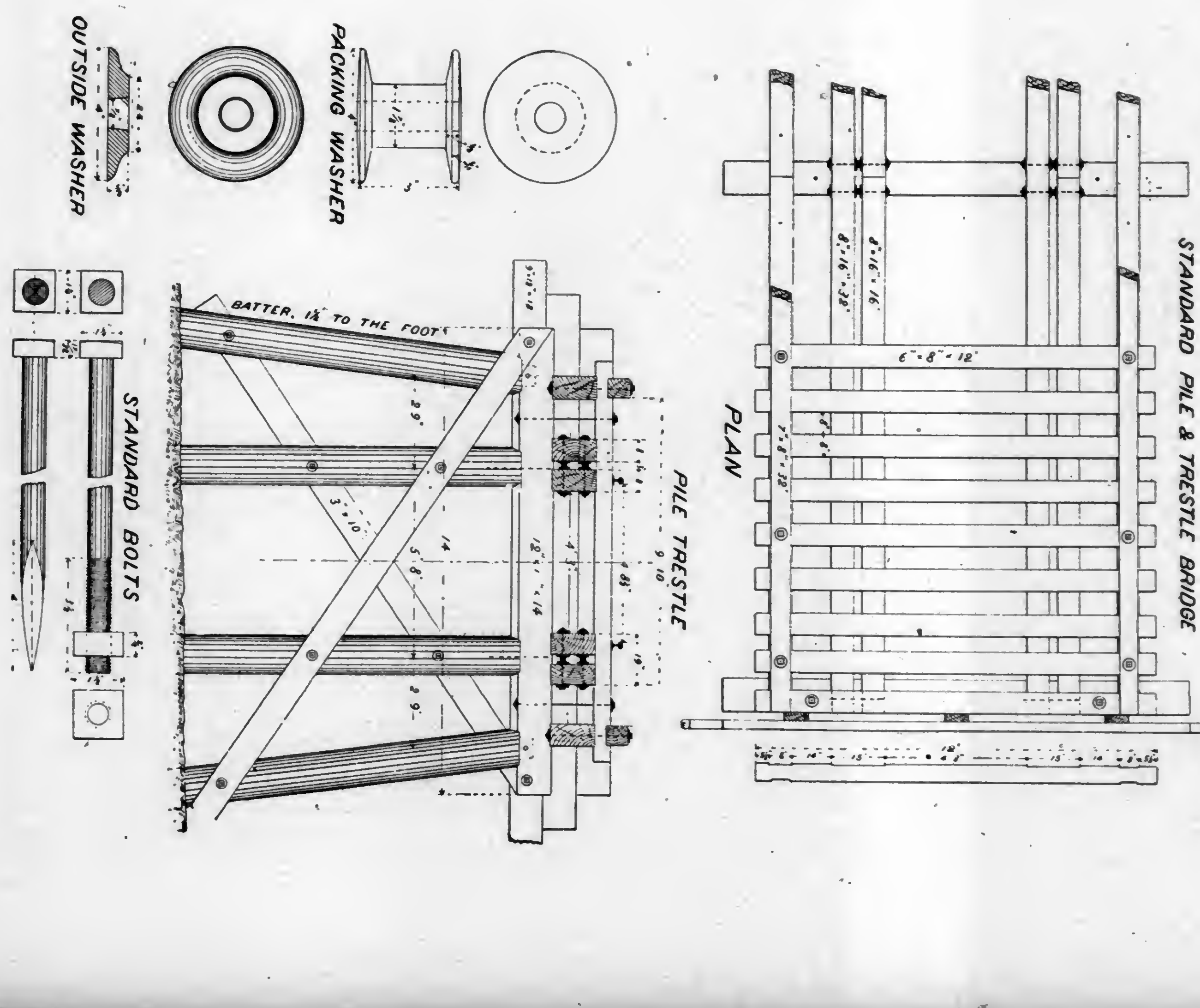
There is one method of fastening the timbers together that has been tried to a certain extent, and, as far as the Author knows, has always given good results. That is by means of bent plates, as shown in Plate 77.* These plates are made from thin boiler-plate ⅛ in. to ¼ in. thick. They can be rapidly and cheaply made in the shops to suit any sized timber used, and any angle at which the timbers meet. There is a minimum of work required in the field, simply squaring off the timber and possibly adzing down the edge until it fits the socket. The timbers are held firmly in place by spiking through the bent sides, as shown in the sketch. The resulting joint has all the stiffness of the mortise and tenon. There is none of the expense attending the cutting of the mortise and tenon, and the metal plates tend to protect from decay the parts

* These bent plates are not used upon the Chicago, Rock Island & Pacific Railroad, and have nothing to do with the standard plans of that railroad that appear upon the same plate.



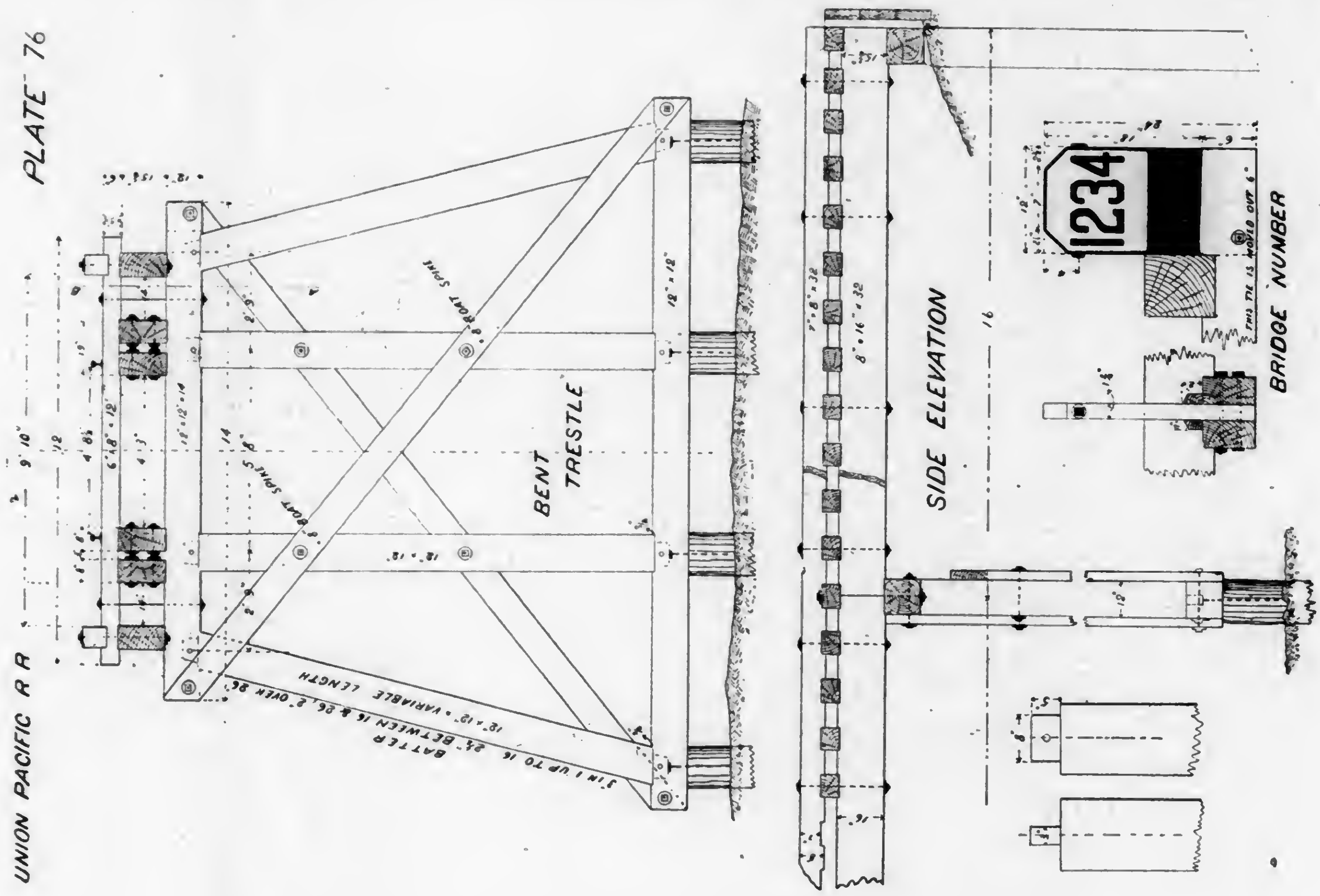
S.J.&I.R.R.
FRAMED BENTS
33 FEET HIGH

PLATE 74



UNION PACIFIC R R
STANDARD PILE & TRESTLE BRIDGE

PLATE 75



of the timber with which they come in contact. We are unable to account for the fact that this method has been so little used, as we know of no instance of its having been used without the result being in every way satisfactory.

One point that should always be studied with much care in all trestle designing is the matter of sway-bracing and longitudinal bracing. The different methods used can be easily understood by an examination of the different plates. For diagonal sway-bracing the simplest and best material to use is 2 in. to 4 in. plank, 6 in. or 8 in. wide, spiked in place. For longitudinal bracing, as will be seen by an examination of the plans, heavier timber is used and in some cases notched into the bents.

In connecting a high trestle with a freshly-made bank, it is always better that the ends of the stringers should rest upon a heavy mud-sill than upon a solid bent. The bank is sure to settle to a greater or less extent, and if the ends of the stringers rest on a heavy mud-sill they settle with the bank. The amount of this settling is seldom enough to cause any trouble, unless the ends of the stringers are on a rigid bent that holds them absolutely in place, in which case the settling is often enough to make a decidedly bad point in the track, and one that needs constant attention.

In most trestles, as in most bridges, the floor is the weak point. The stringers themselves are usually of sufficient size, but the arrangement of the ties, guard rails, etc., is faulty. The stringers should always be packed stringers when the distance to be covered is more than can be spanned by a single stick. By a packed stringer is meant one made up of a number of pieces of sufficient and equal depth placed side by side and bolted together. These pieces should not be placed so as to touch each other, but with a certain space—about 1 in.—between them. In some cases they are held apart by means of cast-iron spools, as shown in some of the plates, while in other cases they are held apart by means of packing blocks. They are held together by means of ¾-in. packing-bolts having a head, nut, thread, and washers; one great advantage of packed stringers is that in this way it is possible to break joints thoroughly and practically to make a stringer of any dimension or any length.

In designing the stringer pieces there should never come upon one cap more than one joint, when it is possible to avoid it. Between the cap and stringer there should be always a corbel of greater or less length. The object of this corbel is to increase the bearing surface upon which the stringer rests, and also to prevent the crushing of the wood of the stringer under a load, as would be the case if the stringer rested directly upon the cap.

The corbel, being in itself a comparatively small piece of timber, can be renewed whenever necessary at very little trouble and expense. Notwithstanding this gain due to the use of corbels, an examination of the standard plans here presented will show that upon many roads they are not used, the stringers resting directly upon the caps.

Besides the main stringers that come directly under the rail there should always be outside stringers that either come under the guard-rail, or outside of it. These outside stringers need not be more than half the dimensions of the main stringers. Their object is to hold up the train in case it is derailed, preventing the ties from giving way when the weight of the train is brought directly upon them, as would be the case if they were unsupported near their ends. The dimensions of the stringers depend upon the length of clear span and the weight of the locomotive used. These can be easily calculated in each case.

The weak point in nearly ever floor system is the ties. They are too small—often too short—and almost universally too far apart. The principal object for which ties are used is to furnish a floor of sufficient strength to support the weight of a train if it should chance to come on to the trestle with some of its wheels off the track, or if it should become derailed while upon the trestle. So far as the mere supporting of the rails go, and the holding of them to gauge, there are a number of methods by which this could be done at less expense, and in fully as effective a manner as by the use of cross-ties. This last remark, of course, must be understood to apply to the supporting

of rails upon bridges, trestles, or similar structures, and not upon the ordinary embankment.

There is one device which, in the majority of cases, would prevent any trucks of a train being off the track when a trestle or bridge is reached, and that is some one of the many rerailing devices. Plans and descriptions of the best of these devices will be given later; for the present we will only say that it is of very rare occurrence that the wheels of a car or locomotive leave the track while upon a bridge or trestle, so that by having one of the rerailing devices at the approach to every bridge or trestle about 90 per cent. of the danger is done away with. Still there is always the possibility that first, the rerailing device may not in every case effect the object for which it is built, and second, that a car or locomotive may from some cause become derailed upon the bridge or trestle itself. In order to reduce to a minimum the evil results following such an accident, the floor of the bridge should be such that the wheels, even if not upon the rail, can run across it, and they should also be prevented from swinging round too far, or getting too great a distance from the track.

In order to prevent the wheels from dropping through the floor, and thus tearing it up, the ties should not be more than 6 in. or 7 in. apart in the clear, and should be of such a section as not to break under the hammer-like blows they will receive when a wheel or pair of wheels is bouncing over them. They will have to be fastened also in some manner that will prevent them from being bunched or driven together by these blows from a derailed truck. The usual size of tie used, as will be seen by the drawings, is 6 in. × 8 in., and they are generally placed 7 in. apart in the clear. With the present tremendous weight of locomotives and rolling stock used, the ties should not be less than 8 in. × 12 in. and placed 6 in. apart in the clear. The length of the tie should not be less than 12 ft., although 9 ft. is the usual length. This question of length will be taken up more fully later on.

With regard to holding the ties in place, they rest directly upon the main stringers and the outside stringers; on top of the ties rest the rails that are spiked to each tie. This spiking, however, does very little to prevent the ties from being bunched in case of accident, as the heads of the spikes slip easily along the flanges of the rail. On each side of the track, and about 4½ ft. or 5 ft. from the center, are placed the guard-rails. These guard-rails are usually 8 in. × by 8 in. in size, and they should be notched down over the ties at least 1 in. The outside stringers should be directly under the guard-rail, and then ¾-in. bolts, with head and nut, should pass through the guard-rail, tie, and outside stringer, and thus everything be firmly bolted together. These bolts need not be used at every tie, but about every third tie will be sufficient. At points near bents these bolts should run down through the ends of the corbels, if they are used; if not, everything should be bolted directly to the cap. In every case these bolts should have a head and nut and not be drift-bolts. When this guard-rail is properly notched down over the ties and then firmly bolted in place, it will be impossible for the ties to become bunched in case of accident.

The object of the guard-rails is to prevent the wheels, when off the track, from running too near the edge, and to guide them in their course across the bridge; also to prevent the trucks from getting slowed to such an extent as to catch between the ties and tear them up. The upper inside angle of these guard-rails should be protected by a ¼-in. angle-plate, firmly spiked to place. This will not only tend much to preserve the timber, but will also do away to a great extent with the danger of any derailed wheel mounting the guard-rail and thus getting upon the outside of it. With regard to the length of cross-ties, as was said before, they should be not less than 12 ft. In the first place, this gives sufficient room to properly arrange the guard-rail; it also adds much, or may be made to add much, to the stability of the structure. In the second place, it affords sufficient space to allow of a man being on the structure while a train is passing. This is something that should always be thought of, especially in long trestles. In very long trestles there should always be some arrangement made for holding the hand-car of the section gauge when necessary. There are some few examples in this country where this has been provided for, but they are altogether too few.

Herewith are given the bills of material for the pile and trestle bridges shown in the accompanying plates:

No. 35. Bill of Material for One Bent and Span of Bent Bridge, Denver & Rio Grande Railroad. Plates 68 and 69.

Lumber.

Description.	No. of Pieces.	Dimensions.	Ft.BM.
Guards	1	7 in. × 8 in. × 32 ft.	149 1/3
Ties	16	8 in. × 8 in. × 12 ft.	1,024
Stringers	3	8 in. × 16 in. × 32 ft.	1,024
Caps	1	12 in. × 12 in. × 14 ft.	168
Posts	4	12 in. × 12 in.	
Sills	1	12 in. × 12 in.	
Bracing	2	3 in. × 10 in.	
Plank for ends	3	3 in. × 8 in. × 3 ft.	18
" " "	1	3 in. × 12 in. × 14 ft.	42
" " "	1	3 in. × 12 in. × 16 ft.	48
" " "	1	3 in. × 12 in. × 18 ft.	54

Iron.

Description.	No. of Pieces.	Dimensions.
Bolts, packing	8	¾ in. × 22 in.
Bolts, tie to cap	2	¾ in. × 38 in.
Bolts, guard-rail	8	¾ in. × 33 in.
Bolts, bracing	8	¾ in. × 18 in.
Bolts, drift	4	¾ in. × 18 in.
Washers, packing	8	¾ in. × 3 in. × 4 in.
Washers, outside	52	¾ in. × ⅝ in. × 4 in.
Spikes, boat	20	½ in. × 8 in.

No. 36. Bill of Material for One Bent and Span of Pile Bridge Denver & Rio Grande Railroad. Plates 68 and 69.

Lumber.

Description.	No. of Pieces.	Dimensions.	Ft. BM.
Guards	1	7 in. × 8 in. × 32 ft.	149 ⅓
Ties	16	8 in. × 8 in. × 12 ft	1,024
Stringers	3	8 in. × 16 in. × 32 ft.	1,024
Caps	1	12 in. × 12 in. × 14 ft.	168
Piles	4		
Bracing	2	3 in. × 10 in.	
Plank for ends	3	3 in. × 8 in. × 3 ft.	18
" " "	1	3 in. × 12 in. × 14 ft.	42
" " "	1	3 in. × 12 in. × 16 ft.	48
" " "	1	3 in. × 12 in. × 18 ft.	54

Iron.

Description.	No. of Pieces.	Dimensions.
Bolts, packing	8	¾ in. × 22 in.
Bolts, tie to cap	2	¾ in. × 38 in.
Bolts, guard-rail	8	¾ in. × 33 in.
Bolts, bracing	8	¾ in. × 18 in.
Bolts, drift	4	¾ in. × 22 in.
Washer, packing	8	¾ in. × 3 in. × 4 in.
Washer, outside	52	¾ in. × ⅝ in. × 4 in.
Spikes, boat	18	½ in. × 6 in.

We wish to call especial attention to the standard framed bents of the St. Joseph & Iowa Railroad, as shown in Plates 70 to 74 inclusive. The characteristic points in these designs is that much smaller timber is needed than is generally used in the construction of bents of such a size, no timber being larger than 8 in. × 12 in., 16 ft. long, with the exception of the caps, which are 12 in. × 12 in. There is no timber required in the construction of these bents that cannot be purchased at any lumber yard, and it would well repay engineers to put more study upon designs requiring only timber of the ordinary dimensions.

Plate 78 shows a rather novel design of a built beam that has been used with much satisfaction upon the New

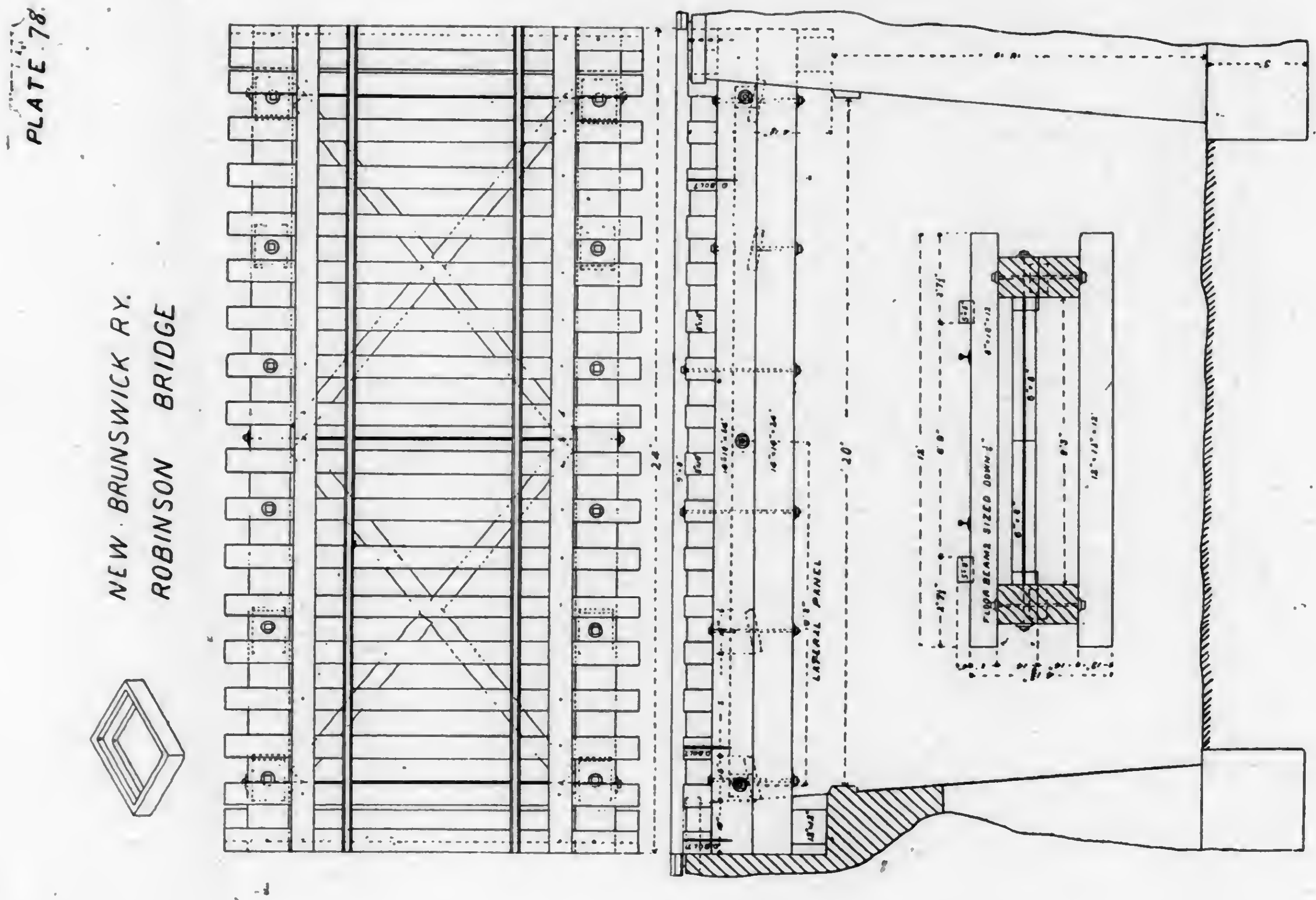


PLATE 78.
NEW BRUNSWICK RY.
ROBINSON BRIDGE
LATERAL PANEL
FLOOR BEAMS SIZED DOWN

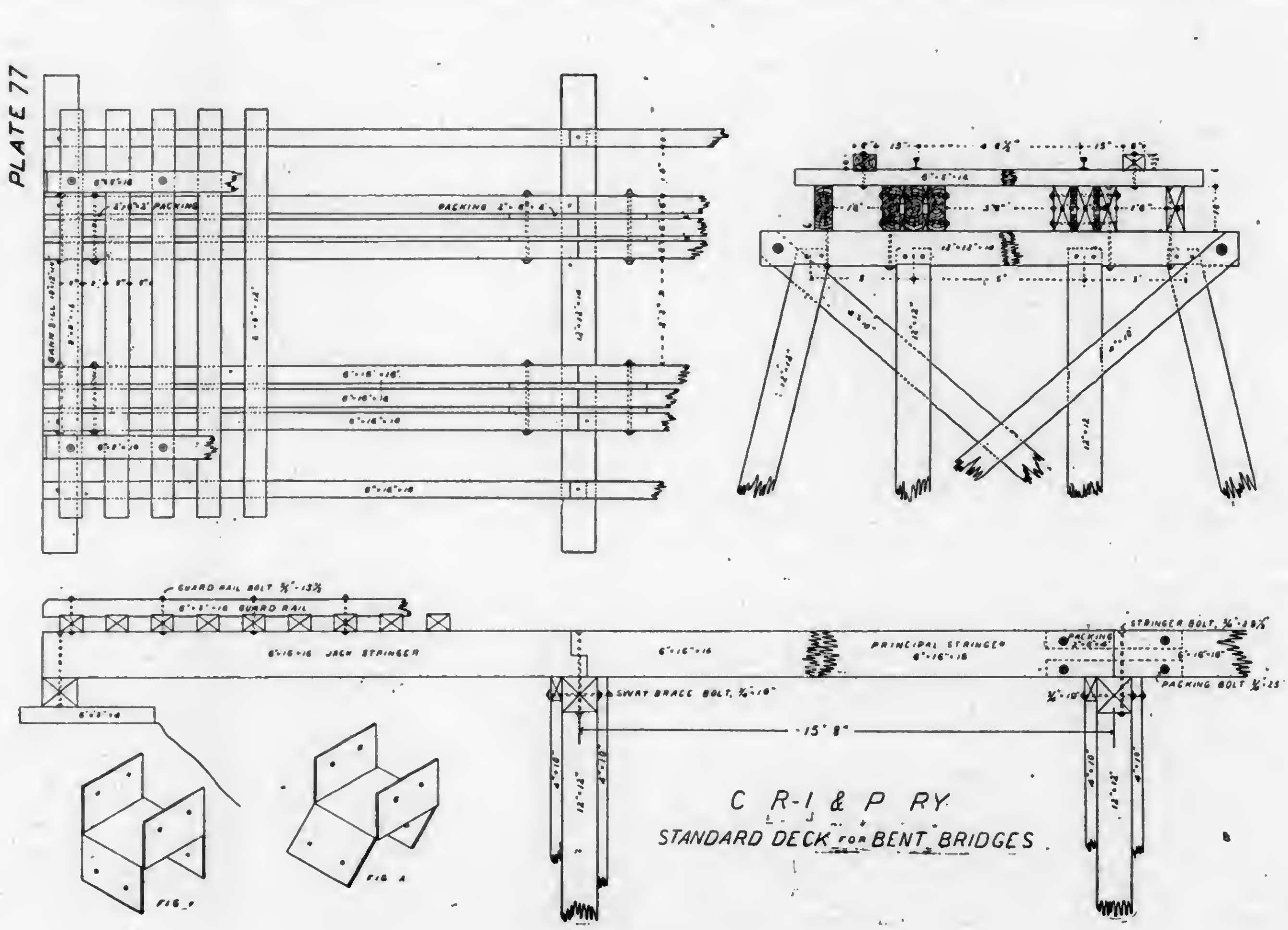


PLATE 77
GUARD RAIL BOLT
GUARD RAIL
JACK STRINGER
PRINCIPAL STRINGER
STRINGER BOLT
SWAY BRACE BOLT
PACKING BOLT
15' 8"
FIG. A
C R-I & P RY.
STANDARD DECK FOR BENT BRIDGES

No. 37. Bill of Material for One Bent and Span of Trestle Bridge, Union Pacific Railway. Plates 75 and 76.

Lumber.

Description.	Kind.	No. of Pieces.	Dimensions.	Ft. BM.
Sills	Pine.	1	12 in. × 12 in.	
Posts	"	4	12 in. × 12 in.	
Caps	Oak.	1	12 in. × 12 in. × 14 ft.	168
Stringers (see note)	Pine.	6	8 in. × 16 in.	1,024
Ties	Oak.	12	6 in. × 8 in. × 12 ft.	576
Guards (see note)	Pine.	2	7 in. × 8 in.	149
Bracing	Oak.	2	3 in. × 10 in.	
Plank for end span	Pine.	1	3 in. × 12 in. × 14 ft.	42
" " " "	"	1	3 in. × 12 in. × 16 ft.	48
" " " "	"	1	3 in. × 12 in. × 18 ft.	54
" " " "	"	3	3 in. × 12 in. × 3 ft.	18

Note.—Guards and stringers 32 ft. long, breaking joints.

Iron.

Description.	No. of Pieces.	Dimensions.	Weight
Bolts, packing	8	¾ in. × 22 in.	26.6 lbs.
Bolts, tie to cap	2	¾ in. × 36 in.	10.1 "
Bolts, tie to stringer guard	8	¾ in. × 31 in.	35.5 "
Bolts, bracing	8	¾ in. × 18 in.	22.5 "
Washers, packing	8	¾ in. × 3 in. × 4 in.	
Washers, outside	52	¾ in. × ⅝ in. × 4 in.	
Spikes, boat	20	½ in. × 8 in.	
Drift-bolts where piles are used	4	¾ in. × 18 in.	

Note.—Use either the Harvey nut, or jam-nuts.

No. 38. Bill of Material for One Bent and Span of Pile Bridge, Union Pacific Railway. Plates 75 and 76.

Lumber.

Description.	Kind.	No. of Pieces.	Size.	Ft. B. M.
Piles	Oak.	4		L. F.
Caps	"	1	12 in. × 12 in. × 14 ft.	168 BM.
Stringers (see note.)	Pine.	6	8 in. × 16 in.	1,024 "
Ties	Oak.	12	6 in. × 8 in. × 12 ft.	576 "
Guards (see note.)	Pine.	2	7 in. × 8 in.	149⅓ "
Bracing	Oak.	2	3 in. × 10 in.	"
Plank for end span	Pine.	1	3 in. × 12 in. × 14 ft.	42 "
" " " "	"	1	3 in. × 12 in. × 16 ft.	48 "
" " " "	"	1	3 in. × 12 in. × 18 ft.	54 "
" " " "	"	3	3 in. × 8 in. × 3 ft.	18 "

Note.—Guards and stringers 32 ft. long, breaking joints.

Iron.

Description.	No. of Pieces.	Size.	Weight
Bolts, packing	8	¾ in. × 22 in.	26.6 lbs.
Bolts, tie to cap	2	¾ in. × 36 in.	10.1 "
Bolts, tie, stringer and guard	8	¾ in. × 31 in.	35.5 "
Bolts, Bracing	8	¾ in. × 18 in.	22.5 "
Washers, packing	8	¾ in. × 3 in. × 4 in.	
Washers, outside	52	¾ in. × ⅝ in. × 4 in.	
Spikes (boat)	20	½ in. × 8 in.	
Drift-bolts	2	¾ in. × 22 in.	

Note.—Use either the Harvey nut, or jam-nuts.

Brunswick Railway. It was designed by Moses Burpee, Chief Engineer of the road, to whose kindness the Author is indebted for the plans and description. It is designed to be used when a single stick of sufficient size is not available. The two pieces put together in this manner are nearly as strong as a single stick of the same dimensions. The most economical proportions to be used in this case are about a depth of two to a width of one. The details of construction can be easily understood by a careful study of the drawing. The brace-blocks shown in figs. 1 and 2 are of cast iron. It will be noticed that they are of less width than the timbers with which they are used. The object of this is to obviate the necessity of cutting the edges of the timbers, and thus preventing to a great extent the entrance of moisture to the joint. The number of these brace-blocks used depends upon the length and dimensions of the timber used.

It is well, in designing this beam, to calculate for a camber, which should be about one-half the deflection of a solid beam of the same size under the given load. The object of this is to insure the bottom stick being in tension when loaded. This camber is easily given to the beam by increasing the distance between the seats of the braces in the top stick slightly over those in the bottom stick; the proper amount can be easily calculated. A bolt runs through both sticks and a hole in the center of the brace-block, and holds everything firmly together. To put the beam together, it is necessary to lay the bottom stick "work-wise" and clamp it in shape of camber so as to stretch the top of it sufficiently to receive the brace-blocks and the top stick; or it may be laid straight and the brace-blocks put in place, with their upper ends raised and propped up with a little stick just sufficient to hold the weight of the casting. Then, when the top stick is put in position and the bolts tightened up, the beam will be brought to a camber.

This is only another example of how two small pieces of timber may be made to do the work of one large piece when it is impossible or not advisable to procure the requisite large piece.

(TO BE CONTINUED.)

A NEW RUSSIAN BATTLE-SHIP.

(From the *Morskoi Sbornik.*)

The latest addition to the Russian Navy is the armored battle-ship *Nicholas I.*, which was begun in 1886, and which has been built by the Franco-Russian Company under contract. The vessel is of steel of Russian manufacture, furnished by the Alexandroffski and the Putiloffski Works; the armor-plates were made at the Admiralty Works at Ijorski.

The chief dimensions of the *Nicholas I.* are as follows: Length between perpendiculars, 333½ ft.; length over all, including ram, 347½ ft.; breadth, 67 ft.; average draft, 23 ft.; displacement, 8,440 tons.

The belt armor is continuous, and is 8 ft. 2 in. wide; of this width, at the normal draft, 5 ft. is above the water-line and 3 ft. 2 in. below it. The compound armor-plates are 14 in. thick at the top, diminishing or tapering to 8 in. at the lower edge. The wood backing is of larch. The conning-tower is plated with 8-in. steel, and the turret, in which are carried two 12-in. guns, is plated with 10-in. steel.

In addition to the turret the ship has an armored redoubt or barbette above the main or armored deck, and in this additional guns are carried. In other words, the so-called barbette and turret systems are combined in its design. The turret is operated by hydraulic machinery, and every possible method of economizing space has been used, so as to give room for working the guns.

Provision is made for artificial ventilation below the deck, as well as for supplying forced draft to the boilers. The condensers are double, the first set supplying fresh water to the boilers, while from the second water for drinking purposes, for the supply of the crew, is obtained.

Like almost all modern war-vessels, the ship has twin screws. Each screw is driven by a triple-expansion engine having cylinders 39 in., 57 in., and 85 in. in diameter, and 38½-in. stroke. The engines are so arranged that the low-pressure cylinders can be detached from the others and worked separately. The propellers are of phosphor-bronze, and have four blades each.

There are 12 cylindrical boilers, each with three furnaces. These boilers are independent of each other, so that any injury to one will not affect the others—an important consideration in a fighting ship. The boilers are

each 13 ft. in diameter and 10 ft. long, and carry a working pressure of 125 lbs. The total weight of the machinery and boilers—including water in the boilers—is 1,100 tons.

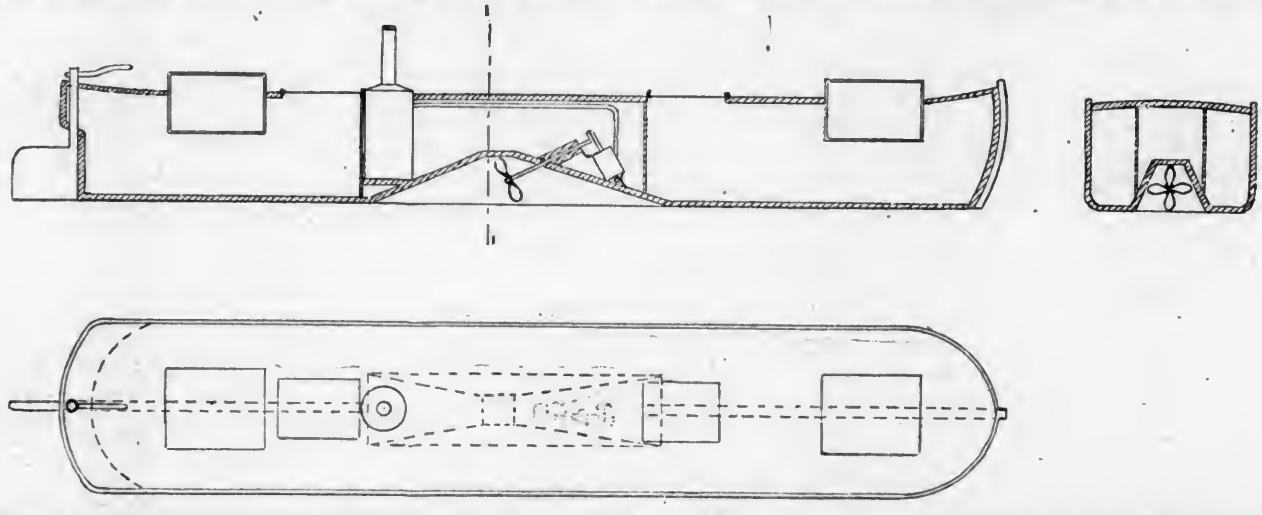
In the contract it was provided that the coal consumption at full power should not exceed 2 lbs. per indicated H.P. per hour. The trials on the measured mile, and also in a six hours' test in continuous working, showed that this condition had been fulfilled. On these trials the engines developed about 8,000 H.P. The speed attained by the ship is not stated.

PROPELLING ON LIGHT DRAFT.

By Aloha Vivarttas.

In view of the recent experiments of M. Oriolle, of Nantes, France, as described in the Railroad and Engineering Journal of December, 1889, perhaps the history of the *Central* of New York may be interesting.

It happened that in the earlier seventies, while a memorable offer of $100,000 for the best method of steam propulsion on canals, made by the State of New York, was yet on the tapis, that a couple of engineers got up a plan for propelling vessels by means of a screw propeller located near the center of the boat, and working in a trunk analogous to that of an ordinary center-board, but wider, and closed over at the top.



The idea was not entirely new, but there was room for a great deal of judgment in carrying it out.

In 1876 a company, consisting of a dozen or more gentlemen, was formed, under the cognomen of the Central Propelling Company, for the purpose of applying the above invention to vessels, especially canal-boats.

An Erie canal-boat was purchased and a hole cut in her bottom, the trunk built in, and engines, boiler and propeller fitted complete.

Her general dimensions, without going into details, were as follows: Length, 96 ft.; beam, 17 ft.; depth, 11 ft.; load draft, 6 ft.; light draft, 2 ft; one propeller, diameter, 5 ft.; two engines, with cylinders 8 in. × 24 in., with boiler, surface condenser, etc. The accompanying sketch gives a fair idea of the general arrangement.

Her displacement at the load line was 240 tons, giving her a freight-carrying capacity of about 185 tons.

When all was complete, and her name duly changed to the more appropriate one of *Central*, a committee of the investors went aboard and the trial trip commenced.

Going up the Hudson light—that is, drawing about 2 ft. of water—she was reported as making six miles an hour easily, and, in spite of some heavy weather in Haverstraw Bay, Albany was passed, and the " raging canawl" boldly entered.

In the passage up the canal the boat puzzled all of her old acquaintances by carrying a smokestack but no apparent propeller, sliding smoothly along at a good rate of speed, which had no visible means of support.

After various incidents, more interesting to the spectators than to the public, Buffalo was reached, a cargo of corn secured, and the *Central* started down the canal.

Of the return trip it is related that, in crossing a long viaduct near Lockport, the boat had but a few inches of water under her keel, yet the propeller had no lack, and the speed was good.

On another occasion something got adrift in one of the steam-chests, and that cylinder was disconnected and the boat driven by one engine only without noticeable diminution of speed, which was easily maintained at 2½ miles per hour.

The voyage ended at New York, and it was found, upon figuring up the books, that the cost of coal and commissary stores had run ahead of the receipts in freight money. But the propeller had done its work well, and demonstrated the correctness of its arrangement and the general plan of the invention.

The patents were now taken out and assigned to the company. The boat was laid up for the winter in Gowanus Bay.

The next spring the *Central* was overhauled, and in June or July, 1877, a second trip was made to Buffalo and back. But by this time dissension had crept into the council chamber, differing men pulled different ways, and the result was that the assets of the company were sold out. The boat returned to her old practice of dancing on a taut tow-line, and the patents dropped out of sight in the safes of some one or two parties who had other matters to attend to, and they have remained in the chrysalis state ever since.

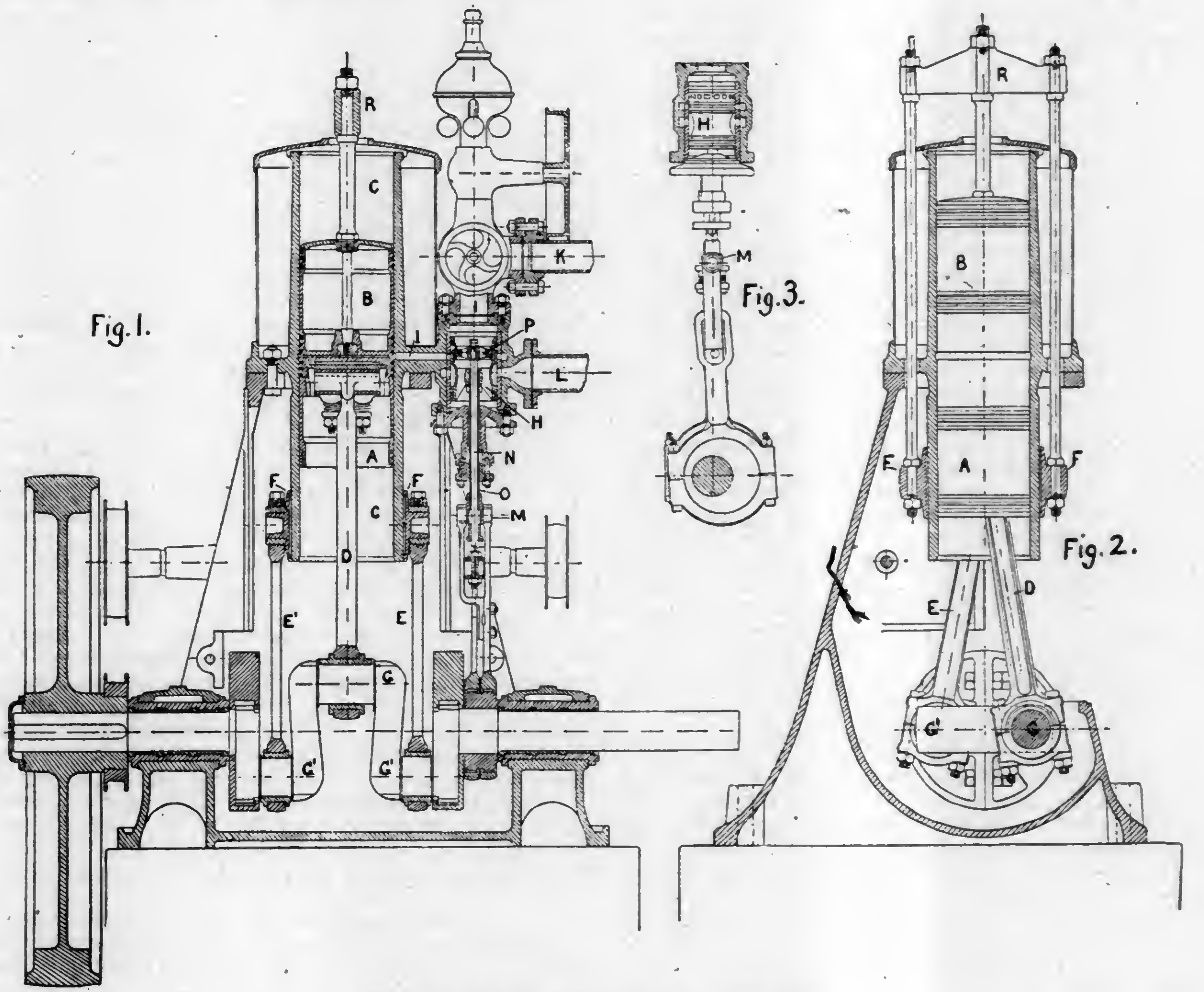
Of this plan of propulsion it may be said, in the light of the above-described experiment, that it has a wide field and is capable of giving good results if properly handled, but, like a blooded horse, it will disappoint the man who does not understand it. It shows, however, that M. Oriolle's plan was substantially anticipated some 13 years ago.

THE BÜRGIN HIGH-SPEED ENGINE.

(From the *Practical Engineer*.)

This is an interesting example of the single-acting type of high-speed engine, which presents some peculiarities special to itself. It is exhibited in the Swiss section of the Paris Exhibition, and is intended to solve the difficult problem of attaining perfect balancing in a high-speed reciprocating engine. The novel departure consists in the use of two pistons, working in a common cylinder, and so connected to the driving cranks that in all positions equal weights of pistons and rods are moving in opposite directions. There have been several attempts to balance by a somewhat similar construction, but this is the first arrangement of a single-acting engine with pistons moving in opposite directions of which we are aware. If we remember aright, Messrs. Lamberton, of Glasgow, exhibited an

engine of the double-acting type, in which this desirable feature was ingeniously accomplished. Referring to our illustrations, fig. 1 is a vertical section through the length of the crank-shaft, fig. 2 is a similar transverse section, and fig. 3 is a separate illustration of the piston valve and eccentric. The lower piston A and the upper piston B work in a long open cylinder C, common to both; and the lower piston connects to the center crank-pin G by the connecting rod D, while the upper piston is attached to a cross-head R by a rod shown, which cross-head connects in turn to a sliding ring $F\ F$ fitting nicely on the machined exterior of the lower end of the long cylinder C. Connecting rods $E\ E^1$ link this sliding ring to two crank-pins, G^1 a stuffing-gland driving the internal expansion valve P. The piston-valve is therefore double, and consists of an internal and an external piston. The external serves as the ordinary main steam-valve, while the internal serves as the expansion or cut-off valve. They are driven by separate eccentrics. The live steam is admitted by the pipe K and passes through the interior of the piston-valve by ports shown more clearly in fig. 3. The valve is single-acting, of course, as the engine is single-acting. The exhaust escapes at the proper time by the annular passage shown in the exterior of the main piston-valve, and by the pipe L. The governor is of the throttle type, and is part of the inlet steam valve. The governor is driven by belt



THE BÜRGIN HIGH-SPEED ENGINE.

G^1, which are formed by bending, so that their centers fairly oppose the pin G—that is, the pins are separated on the crank circle by 180°, or half a circle. The construction of such a crank-shaft requires care, to ensure the two pins $G^1\ G^1$ being truly in line; and as space is highly important, the arrangement is somewhat unusual. However, we shall describe that point directly. Steam is admitted between the pistons by the port I, controlled by the piston-valve H. In the position shown in fig. 1, the exhaust stroke has just been completed, and the steam is about to be admitted; the two pistons are thereby pushed apart, and the position at about half stroke is shown at fig. 2. When the stroke is completed, the exhaust is opened, and the pistons return to meet in the middle, as shown in fig. 1. By arranging the weights of the two pistons and their connections to be equal to each other, a most perfect balance is secured, and high speeds can be readily run with the greatest smoothness.

We are informed that this engine runs at 500 revolutions per minute without the smallest vibration. The piston-valve H is actuated from the eccentric rod M, through the sleeve or hollow rod O, in which works the rod N, through from the main shaft by the pulleys and intermediate shaft seen in fig. 1. The cranks $G\ G^1\ G^1$ are formed by bending, and are connected to the crank-shaft by disks, made in halves and bolted together, as may be seen from figs. 1 and 2. The connecting rods are of special construction, and have springs, arranged as shown in fig. 1, to keep the brasses tight and prevent knock on the up-stroke. It is a common belief that pressure is always upon the crank-pins of single-acting engines, because there is no driving effort from steam upon the idle stroke; but this is a mistake. During the first half of the idle stroke there is always pressure upon the crank-pin, because the pin is doing work upon the piston and connecting rod, by causing their motion to be accelerated; but during the latter half of the stroke the piston is pulling on the crank-pin, as the speed is slowing down. Unless the cushioning is very early and great, this cannot be avoided. By using springs, Mr. Bürgin insures that all slack shall be taken up, and this avoids shock when nearing the end of the stroke.

Mr. Bürgin's engine is constructed by the Société de Constructions Méchaniques, Bâle, Switzerland, and is well

worth careful study as a most ingenious piece of mechanism, which possesses many good points. The whole design is neat and substantial, and quite worthy of the high reputation of the Swiss makers.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

CHEMISTRY APPLIED TO RAILROADS.

II. TALLOW.

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page* 557, *Vol. LXIII.*)

TALLOW is used by railroads principally as a cylinder lubricant. It is also used, to a limited extent, mixed with white lead ground in oil, as a means of protecting the bright work of locomotives and other machinery from corrosion, when from any cause they are taken out of service for a period of time. It is also used somewhat in treating hot boxes on the road, and may be used as a constituent of lubricants. On some railroads tallow-oil is used by preference in place of tallow. The principal use of tallow, however, so far as our knowledge goes, is everywhere as a cylinder lubricant. The amount used for this purpose is so great, that the figures, to one unaccustomed to railroad accounts, seem almost incredible. Any large railroad company may use on its lines, in one year, from 750,000 lbs. to 1,000,000 lbs. of tallow, at a cost of from $60,000 to $80,000, by far the largest portion of this amount being used for cylinder lubrication. It is gratifying to be able to state, that with the introduction of sight-feed cups, the use of tallow as a cylinder lubricant is diminishing largely, and in view of the difficulties which seem to be inseparable from the use of this material, railroad operating officers will certainly welcome the day when its use can be dispensed with entirely.

In order to make clear what follows, it will be necessary to get a full understanding of what tallow is. Speaking chemically, tallow is principally a mixture of three neutral fatty bodies, known as stearin, palmitin, and olein. The stearin is about 61 per cent., the palmitin is about 6 per cent., and the olein is about 33 per cent. of the tallow. The stearin and palmitin are solids at ordinary temperatures, the melting point of stearin being from 123° to 157° Fahrenheit, and of palmitin a little less. Pure olein is a liquid at ordinary temperatures, and becomes hard at something below 40° Fahrenheit. Tallow oil is largely olein mixed, however, with more or less of palmitin and stearin. Each of these three chemical bodies consists of a characteristic acid chemically combined with glycerine, the stearin being stearic acid combined with glycerine, the palmitin, palmitic acid, and the olein, oleic acid combined with glycerine. It is, perhaps, more correct to say that when stearine, palmitin, or olein breaks up, stearic, palmitic, or oleic acid and glycerine are formed, water being absorbed in the process. In other words, stearin is stearic acid combined with glycerine, minus the elements of water, the water separating when the combination takes place. The point which we want to make is that these neutral fatty bodies contain an acid. The glycerine is a small percentage of the total weight of the tallow.

When the fat exists in the animal, at least if the animal is in a healthy condition, the three principal constituents of the tallow are, as stated above, simply neutral fatty bodies, enclosed in little membranous sacs in the fat tissues. In order to secure the tallow, and separate it from the tissues, heat alone is at present made use of—so far as our knowledge goes, at least. It is commonly believed that dilute sulphuric acid is made use of by many country butchers, to help in separating the fat from the tissue, but in our experience we have never seen any evidence that this method was practised. Generally the fat is thrown into either open kettles along with a very small amount of water, and heat applied, or it may be put in a closed vessel, and the heat communicated to the fat by means of steam pipes inside. In either case the same result follows, namely, the membranous tissues are ruptured and shrivel, and allow the melted fat to separate. At the end of the operation both the water added and the water contained in the tissue has disappeared, and the tissue has shriveled to be a very small proportion of the total mass. These shriveled bits of tissues are known commonly as "cracklings." The tallow is separated from the cracklings by straining and pressure, and is usually marketed in barrels containing about 350 to 380 lbs. each. If these operations are performed in the proper way, and under proper conditions, a tallow results which is almost neutral, as will be readily understood, being simply a mixture of the three neutral bodies above mentioned. In practice, however, it is excessively difficult to secure tallow as it was in the animal—a mixture of neutral bodies. Almost all commercial tallow, when examined in the proper way, shows the presence of more or less free acid, and this acid may vary in amount, from possibly 0.50 per cent. up to as high as 5.00 or 6.00 or 10 00 per cent. of the total weight of the tallow.

The acid just referred to is, so far as known, either one of the three acids which are characteristic of stearin, palmitin, and oleine, or mixtures of them. It is difficult to say which one, if either, predominates. We, of course, are speaking in a general way, and ignore the very small amounts of characteristic volatile fat acids which may be in the tallow. The explanation of this free acid in tallow seems to be that from some cause or causes, the glycerine is separated from the neutral bodies of which the tallow is composed. Experiments have been made by determining the amount of free acid under various conditions, and the following causes are believed to be prominent in increasing the amount of free acid in tallow:

First. If the fat is allowed to stand some hours or days before rendering, especially in warm weather, the amount of free acid will be great. This is, perhaps, very easily accounted for by our common knowledge, namely, that after death decomposition immediately sets in, and, so far as known, the first step in the decomposition of tallow is the separation of the fat acid from the glycerine. Whatever the explanation, definite experiments show that if the fat is rendered within, say, three or four hours after the animal is killed, attention being given to the conditions which follow, the amount of free acid may not exceed 0.50 per cent., even in warm weather. Six hours will bring it up to 0.75 per cent., 24 hours to 1.00 or 2.00 per cent., and two or three days may give a tallow containing as high as 5.00 to 8.00 per cent. of free acid.

Second. High heats increase the amount of free acid. It is difficult to say just exactly why, but perhaps the tendency to saponification by means of the water in the tissues is increased by high temperatures, it being well known that the glycerine in fat acids can be completely separated by water if a high temperature and pressure are employed.

Third. The amount of free acid in the tallow is increased when the rendering is done in closed vessels. This has been demonstrated by positive comparative experiments. Tests of tallow rendered in the same apparatus, in the one case the vessel being closed, and in the other the cover being left off, all the other conditions being exactly the same, showed that the tallow rendered in the closed vessel contained the largest amount of free acid. These experiments were made in the steam-jacketed apparatus used in one of the large abattoirs in Philadelphia. This is accounted for in the same way as in the previous case, namely, by the tendency to water saponification in the closed vessel. Those making tallow to be used as a cylinder lubricant, in which the amount of free acid is desired to be as low as possible, will therefore find it greatly to their advantage to render the tallow as soon as possible after the animal is killed, to avoid high heats, and to do the rendering in open vessels. If proper care is exercised in all of these respects, a commercial article can be made which will contain as low as 1.00 per cent. of free acid the year round.

It will be observed that considerable stress has thus far

been laid on the question of acid in tallow; the reason for this we will now attempt to make clear.

We are so accustomed to regard fats or greases of any kind as an antidote to corrosion, that it may seem singular to state that tallow under certain conditions may be extremely corrosive to iron. As stated in the first article of this series, one of the first questions investigated in the laboratory at Altoona was to find out why the valves and steam chests corroded so badly. It was not at all uncommon to find a valve, which had been in service not over a year, so eaten through under the valve yoke, that live steam from the steam chest would blow through into the exhaust. Also on removing the steam chest the contact between the steam-chest and the top of the cylinder was frequently found badly corroded, and a collection of blackish material always found. It was first thought that the tallow might contain sulphuric acid, introduced during the rendering, as above described. Careful examination of the black material did not show the presence of sulphates, and consequently this theory had to be abandoned. The steam was next charged with the crime, the well-known corrosion of surface condensers in marine engineering being supposed to be a parallel case. On this supposition, however, it was difficult to see why the corrosion should be so largely confined to the steam chest. The dry-pipes and the branch-pipes had equally the effect of the steam, but in no case was the same characteristic corrosion observed. During all this time the thought was prominent, as above stated, that tallow protected the metal surfaces from corrosion, and accordingly the other hypotheses were exhausted before thinking to take hold of the tallow. This view was strengthened by the fact that the best chemical literature at our disposal did not mention any salts of iron formed by the combination of the fat acids characteristic of tallow with iron. Watt's *Dictionary of Chemistry* gave descriptions of stearates and oleates of copper and other metals, but was silent on the corresponding salts of iron. Accordingly, a definite experiment was made by heating cast-iron borings with samples of stearic, palmitic, and oleic acids, the temperature maintained being that of the ordinary locomotive cylinder. Chemical action began before the temperature of the steam cylinder was reached, and continued in the experiment under consideration, as long as the metal and acid were allowed to remain in contact. The action of the acid on the iron produced a brown-looking stearate, palmitate, or oleate of iron. Corresponding experiments were made with tallow containing various amounts of free acid, and in every case the action of the acid on the iron was evidenced both by the formation of the brown salts above mentioned, and by the loss of weight of the iron borings, when separated from the products of the action. No special study was made of these fat acid salts of iron, the point which we were after, namely, whether the fat acids characteristic of tallow act on iron, being demonstrated. The reason why the products of the action of the tallow on the iron, which are found in the steam chests, are black instead of brown, is apparently due to an admixture of dirt, bits of cinder, etc.

This fact being established, the more important question of providing a remedy came into prominence. Obviously, the most natural remedy that would occur would be simply to neutralize the fat acid of the tallow with some alkali. We found this method already in practice by some of the so-called tallow refiners who were making cylinder tallow for the market. Rather inferior tallow of strong odor, and containing large amounts of free acid, was treated in some of the refineries with caustic soda. The soda and the free acid combined, forming, as is well known, common hard soap, and, of course, if the proportions were right, the amount of free acid in the tallow was entirely neutralized. The resulting cylinder lubricant was therefore a mixture of soap and tallow. This seemed like a very reasonable procedure, and it only remained to prove whether this resulting mixture was injurious to the metal. Positive experiments, quite to our astonishment, showed that the mixture of soap and tallow acted on the iron fully as rapidly, if not more so, than the free acid alone. These experiments were repeated many times, and always with the same result. Very pure tallow, containing almost no free acid, was heated up with iron borings to the proper temperature. If the amount of acid is as small as 0.50 per cent. the action is very slight, apparently due to the fact that there is so small an amount of acid and so large an amount of tallow. On dropping into this mixture a small piece of hard soap the action was increased quite largely, and as the result of all our experimentation, it was concluded that this remedy was worse than the disease. It is, perhaps, difficult to account for this behavior of a mixture of soap and tallow. The most reasonable explanation that we could suggest was that the soda of the soap gives up its acid to the iron, and by so doing is set free in condition to attack some of the tallow, and that this action goes on, of course, as long as either the iron or unsaponified tallow remain.

The experiments in attempting to neutralize the free acid resulted so disastrously that no further experiments were made in this line. It is possible that some base might be found which would not interchange with the iron in the tallow, but we did not carry on any experiments in this line further, except to attempt to combine glycerine with the free acid of the tallow, our reasoning being, that if we could restore the tallow to its neutral condition, by giving it back the glycerine which it had lost, it would be a satisfactory material. These experiments did not result in anything satisfactory, as although the reaction is a possible one, yet the conditions under which glycerine combines with free fat acid are somewhat difficult to control.

The attempts to neutralize the acid not succeeding as a practical measure, it was finally decided to attempt to obtain from the market a tallow containing the least possible amount of free acid, and the conditions leading to the formation of free acid in commercial tallow, as previously described, were somewhat studied. Early in the work on tallow a method of determining the amount of free acid in tallow was found to be a desideratum. The method employed is based on the fact that the free acids of tallow are quite soluble in ordinary alcohol, while the tallow itself is only slightly soluble. After a number of modifications and changes, the method finally adopted is given below, as follows:

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Method of Determining Free Acids in Oils and Tallow.

I.—Materials Required.

½ dozen 4-ounce sample bottles.

3 10 cubic centimeter pipettes, or, if desired, a balance weighing milligrams.

1 30 C. C. burette, graduated to tenths [burette-holder if desired], with pinch cock and delivery tube.

2 oz. alcoholic solution of turmeric.

2 qts. 95 per cent. alcohol, to which ½ oz. dry carbonate of soda has been added and thoroughly shaken.

1 qt. caustic potash solution, of such strength that 31½ cubic centimeters exactly neutralizes 5 cubic centimeters of a mixture of sulphuric acid and water, which contains 49 milligrams H_2SO_4 per cubic centimeter.

II.—Operation.

Take about two ounces of the clear alcohol and add a few drops of the turmeric solution, which should color the alcohol red, warm to about 150° Fahrenheit, then add 8.9 grams of the oil to be tested and shake thoroughly. The color of the solution changes to yellow. Fill the burette to the top of the graduation with caustic potash solution, and then run this solution from the burette into the bottle, little at a time, with frequent shaking, until the color changes to red again. The red color must remain after the last thorough shaking. Now read off how many cubic centimeters and tenths of the caustic potash solution have been used, and this figure shows whether the material meets specifications or not.

To determine the free acid in tallow, everything is done exactly as above described, except that the tallow is melted before it is added to the alcohol.

Ten cubic centimeters of extra lard oil, at ordinary temperatures, and the same amount of melted tallow at 100° Fahrenheit, weigh almost exactly 8.9 grams. In ordinary work, therefore, it will probably not be necessary to weigh the oil or tallow. Measurement with a 10-cubic centimeter pipette, will usually be sufficiently accurate, provided the pipette is warmed to about 250° Fahrenheit, and allowed to drain, the last drops being

blown out. In case of dispute, however, the balance must be used.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., February 16, 1889.

With regard to above circular it may be explained that the dry carbonate of soda is added to the ordinary commercial alcohol, because almost all commercial alcohol contains small amounts of acid, probably acetic, and, as will be readily understood, this acid would be counted as fat acid in the tallow if it was not neutralized. The addition of the small amount of carbonate of soda obviates this difficulty. The caustic potash solution required can be obtained in the market from any good dealer in chemical supplies. The turmeric solution is simply an indicator, it being well known that when turmeric solution is acid the color is yellow, and when alkaline it changes to a bright red. The use of phenol-phthalein as an indicator, does not give the same results as turmeric, when used with fats which have undergone considerable decomposition. No investigation has been made as to why this is true, nor are we sure which indicator gives the most accurate results.

The method used will doubtless be clearly understood. The fat acid being dissolved in the alcohol, the addition of the caustic potash solution combines with it, forming potash soap, which remains dissolved in the alcohol. When all the acid has been saturated with potash the color of the solution changes to red and the amount of acid is known from the amount of potash solution required. At first we were accustomed to give the results of free acid in percentages by weight, but in view of the fact that there may be any one, or mixtures of three different fat acids present, which acids differ in molecular weight, this method does not give quite accurate results, and was accordingly abandoned. The acceptance or rejection of tallow or oils in which the acid is determined, is now based upon the amount of standard alkali required to neutralize the acid. The limiting figures given in the specifications for tallow below do not differ far from 1.50 per cent. by weight of free acid in the tallow.

As the result of the whole study of this subject, including the method of determining free acid, and the conditions which lead to the formation of free acid in commercial tallow, as already described, specifications were prepared, and an attempt made to secure tallow in accordance with them. As has proven true in almost every case of new specifications issued by the Pennsylvania Railroad Company, during the last 14 years, considerable difficulty was experienced at first in getting material that would fill the requirements. Those who were rendering tallow had not been accustomed to have any careful examination of their product made, and many of them were very careless indeed. During the first six or eight months after the specifications were issued, it was found excessively difficult to get tallow enough, that would fill requirements, to supply the road. Gradually, however, as the manufacturers have learned to treat the material better, and especially to render the tallow quickly after killing the animal, the difficulties have disappeared, and for a long time very few rejections of tallow have taken place. The specifications first issued were revised from time to time as new information was obtained. The copy given below represents the specifications now in force. It is gratifying to be able to state, that although the specifications do not give a tallow for use in steam cylinders which entirely obviates corrosion, as above described, the first issue of tallow specifications was followed by a large diminution in the replacing of valves. After the specifications had been in force nearly two years the different Master Mechanics of the road were requested to state how the valves were behaving compared with the two years previous, without knowing what this information was desired for. In every case the statement came back that there was not as much trouble with corrosion of valves as had previously been experienced. The experience of the past six or eight years has confirmed this view, and it is, perhaps, not too much to say that from being a very annoying source of trouble, the repair of valves has diminished to a very insignificant item.

It is not hoped, however, that the specifications for tallow will ever entirely prevent the difficulty. As long as the tallow contains any free acid there will be some corrosion. Mixing high fire-test petroleum with tallow, as has been done in many cases for cylinder lubricant, is advantageous in diminishing the amount of free acid in the mixture. As already stated, the use of sight-feed lubricators, which use an oil containing very small amounts of any fatty acid, and which diminish largely the amount of lubricant used, will, undoubtedly, sooner or later, make any serious difficulty of valve or steam-chest corrosion a thing of the past. The present tallow specifications are as follows :

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Tallow.

Tallow for use in locomotive cylinders should contain the least possible amount of free acid, and should, at the same time, be as free as possible from dirt, *cracklings*, and fiber. In order to secure such tallow the following specifications have been adopted :

1. Tallow which, on inspection, is found to contain dirt or *cracklings* disseminated through it, or in streaks, or which has a layer of dirt or *cracklings* in the bottom of the barrel more than an eighth of an inch thick, will be rejected.

2. Tallow containing more free acid than is neutralized by three cubic centimeters of standard alkali will be rejected. The standard alkali, and directions for determining free acid are given in the circular, "Method of Determining Free Acids in Oils and Tallow," which will be furnished on application.

3. Tallow containing soap, or other substances not properly belonging to tallow, will be rejected.

To persons furnishing tallow, who may not have appliances for determining the amount of free acid in tallow, it may be said, that if the fat is rendered within twelve (12) hours from the time the animal is killed, using a temperature of not more than 225° to 250° Fahrenheit during the rendering, it is believed that the free acid in the tallow will be less than amount specified above. In very warm weather it may be necessary to render the fat in less than twelve (12) hours after the animal is killed.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., January 24, 1883.

The reason for each of the requirements in above specifications are, perhaps, all sufficiently evident from what has preceded. It is often found that tallow received from the country butchers contains rather large amounts of cracklings in a fine state of division. This results from using severe pressure in separating the tallow from the cracklings. Of course this material is inferior, and it is necessary to put a limit on the amount received. The examination of tallow, for soap and other impurities, is usually made by burning off the tallow, the soda of the soap remaining behind. Our experience for several years now indicates that there is very little attempt made in the market at present to remove the free acid by neutralization. The ordinary adulterations of tallow in the market are the addition of makeweights, consisting of soapstone, tripoli, or other substances of similar nature, and the admixture with the tallow of other fatty bodies or oils. In our experience it is very rare that a makeweight of any kind is added. If a barrel of tallow weighs over 380 lbs., exclusive of the barrel, it is a suspicious circumstance. Of course the amount of makeweight, if it is mineral matter, can be determined by burning the tallow and weighing the residue, or if soap is absent, by dissolving out the fat in ether or gasolene and weighing the residue.

Quite early in our work on tallow we found serious adulteration arising from the addition of petroleum products to the tallow. In one case no less than 20 per cent. of the weight of the tallow as received, was simply what is known in the market at present as paraffine oil, and what was known at that time as neutral oil. Nearly half of the oil added to the tallow became a vapor at the temperature of the steam cylinders, and, consequently, was worthless for lubrication. In addition to this, the oil cost in the market at that time three or four cents per pound, while the tallow was being sold at 11 cents per pound. This kind of adulteration is very rarely attempted at present, and is readily

detected both by the change of color of the tallow, if any of the cheaper grades of petroleum are used, and by a quantitative saponification by well-known chemical methods, if any white non-saponifiable substance is the adulterant.

A very peculiar treatment of tallow arose in our experience some years ago, consisting in this: On a certain railroad, to which a certain dealer was furnishing tallow, the little bits of the ends of the candles used in car lighting were sold to the dealer. He, very innocently, as is believed, melted up these bits of candles, added them to the tallow, and then sold the tallow to the railroad company, to be used as cylinder lubricant. This, of course, would cause those who are well informed on the subject to smile, since the ordinary car candle is pure and simple stearic acid, as near as it can be obtained pure in a commercial process, and in reality the dealer was adding to the tallow what the chemist had for some time been studying how to exclude from it. An examination made of several samples of this tallow showed free acid as high as 15.00 to 20.00 per cent., which is what we would expect. There was no attempt at concealment in this case; indeed, the practice was well known to the officers of the road, and it could hardly be classed as an adulteration, but as, rather, one of those cases which show the value of a little chemical knowledge in railroad operation. It is hardly necessary to add that the practice was abandoned as soon as the free acid determinations were made.

As stated at the outset, the use of tallow as cylinder lubricant is largely diminishing, and it is probable that within a few years its use will disappear almost entirely. For the benefit of those who are gradually going out of the use of tallow, it may, perhaps, be stated, that if the change is made suddenly from tallow to any of the well-known cylinder lubricants, very serious difficulties are apt to result. The reason for this is that most of the cylinder lubricants of the market consist largely of high fire-test petroleum, which petroleum is a solvent for the binding material of the black substance which, as has been previously described, is contained in the cavities of the valve, and around the edges where the steam chest joins to the cylinder, and also to the steam chest lid. The dissolving out of this substance sets free a large amount of grit and other material which gets between the surfaces and increases the friction enormously. An attempt to use petroleum alone as a cylinder lubricant on engines which had previously been using tallow, might result in breaking the rocker-shafts, and would certainly seriously strain the valve gear. This difficulty can be avoided if the change from tallow to cylinder lubricant is made gradually. Mix with the cylinder lubricant at least one-half extra lard oil for the first month, and gradually diminish the amount of lard oil from month to month. This subject will be referred to again under the head of Cylinder Lubricant.

(TO BE CONTINUED.)

THE NEW TORCY RESERVOIR.

THE great works undertaken in 1881 by the French Government on the Canal du Centre had for their object the enlargement of the cross-section of the canal and the lengthening of the locks. As a consequence it became necessary to increase the supply of water for the canal, and for that purpose a new reservoir has been constructed at Torcy, in the neighborhood of the great steel works of Creusot. This work was begun in the year 1883 and was finally completed and the reservoir filled in July, 1888. To distinguish it from the old reservoir near by, it is called the New Torcy Reservoir. It is situated a little over three miles from the main line of the canal, and the dam is near the village of Torcy. In the accompanying illustrations, fig. 1 is a map showing the position and plan of the reservoir.

The bottom of the reservoir is principally red sandstone, a rock which underlies much of the ground in the vicinity. The surface overflowed is about 412 acres; the reservoir itself is 9.32 miles in circumference; the greatest depth 47½ ft., and the storage capacity 309,600,000 cub. ft. With this assistance the supply of water for the summit level of the canal will be about doubled in the dryest season.

At one end of the dam a channel 39.3 ft. wide is provided for overflowing water. At the end of the dam also a watchman's house and storehouse are erected.

The dam itself, which at both ends is strongly anchored to the hill-side, is built of well-mixed clay and sand well rammed together, the mixture being about 66 per cent. of sand and 34 per cent. of clay. Its total length is 1,432 ft.; width at the top, 8.04 ft.; at the bottom, in the deepest part, 173.5 ft.; the greatest height is 43.5 ft., and the cubic contents of the dam are about 168,700 cub. yds. The slope of the dam on the water side is faced with masonry work 1.64 ft. thick, which is built upon a bed of broken stone and concrete and which rise, as shown in fig. 2, at an angle of 45° in steps 4.92 ft. in height broken by flat berms or treads 2.95 ft. in width. The outer side of the dam, which is built with a slope of 1 : 2.73, is not faced, but to a height of some 16.5 ft. from the bottom is

Fig. 1.

planted with acacias. The top of the dam, which is 5.9 ft. above the highest level of the water, is faced with stone, which is a continuation of the masonry work on the inner side, and across the top runs a wall 3.94 ft. in height.

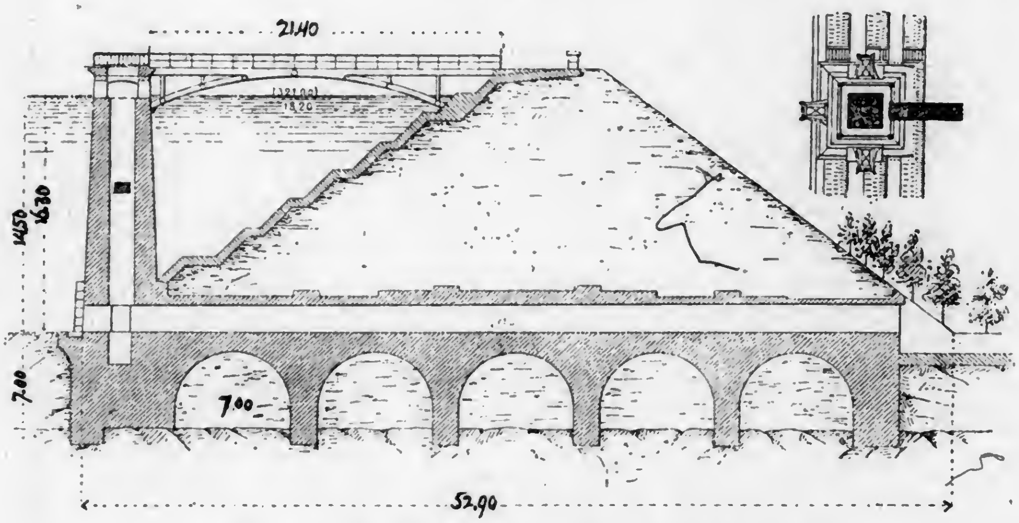
On the water side, for the whole length of the dam, runs a bed of masonry about 5 ft. in depth upon which the bottom of the facing masonry rests, and which is carried 3.28 ft. below the surface of the ground. Before building this masonry, or beginning the construction of the dam, the ground was carefully cleared off to the rock, and in addition two trenches 3.28 ft. in depth were carried the whole length of the dam in order to provide a better connection between the ground and the dam itself.

The clay for the dam was laid in layers 4 in. thick, and then rolled down hard with steam and horse rollers. In building it was found that with a steam roller weighing about 5 tons, about 650 cub. yds. could be rolled in a day's work. The cost of putting in place and rolling down the material for the dam was 3.35 cents per cubic yard.

The bottom of the waste canal is 2.3 ft. below the usual level of the water. This canal is closed by wooden gates, which open automatically when the water rises above a certain level. The out-take, or channel, through which the water is drawn from the reservoir, is through a water tower, which is built up from the base of the dam on the water side, and which is also used as an overflow or outlet for

the water when it rises above the average level. Fig. 2 shows a section of the dam through this tower and the channel, the outer end of which opens into the feeder through which the water is taken to the canal. It will be seen that the masonry of the tower and of the channel are continuous. The openings into the tower are closed by iron gates, which are worked from the platform at the top. The vertical shaft in the tower is 4.92 ft. in diameter and ends in a well 6.56 ft. in depth, which is always full of water in order to prevent any shock or injury to the masonry from the falling body of water in the tower. The openings through which water is admitted are three in number, 13.75 ft. apart, each opening being 15.7 × 31.6 in. in size. These are closed by cylindrical iron gates made on a new plan, and opening in a curve at an angle of 45° to the axis of the tower. A fourth gate of similar construction is placed inside the tower at the bottom; this has an opening 70.9 × 43.3 in. in size into the outlet canal. This is closed by an iron gate carried on a little carriage having four rollers, which runs upon tracks made for the purpose in the masonry. This gate is kept tight by packing-plates of thick rubber. Careful calculations were made in building this gate, and it has been so proportioned that it can be easily worked from the platform at the top of the tower. Since the reservoir has been in use the arrangement has worked very satisfactorily.

Fig. 2.



SECTION OF DAM, NEW TORCY RESERVOIR.

In building this reservoir several auxiliary works were required. It was necessary to make a new location for the railroad line from Nevers to Chagny and for the line connecting with the Creusot Works, and it was also necessary to relocate several roads. The total cost of the reservoir was about $447,000, of which $107,000 was spent for the dam; $116,000 in relocating the railroads and the roads, and the remainder for land and other expenses. The total cost, estimated by storage capacity of water, was about 0.13 cent per cub. ft.

The plans were made by Chief Engineer Fontaine and Engineer Desmur, who also superintended its construction.

UNITED STATES NAVAL PROGRESS.

Perhaps the present condition and needs of our Navy cannot be better shown than by the very interesting report of the Secretary of the Navy, recently submitted to Congress. Accordingly some extracts from that report are given below:

PRESENT CONDITION OF THE NAVY.

The effective force of the United States Navy, when all the ships now authorized are completed, excluding those which, by the process of decay and the operation of law, will by that date have been condemned, will comprise 11 armored vessels, of which only 3 are designed for fighting at sea, and 31 unarmored vessels, making a total of 42.

The following statement shows the number of war-vessels on the effective list of the principal foreign powers, built, building, or projected at the present time, and exclusive of sailing and practice ships:

Country	Armored.	Unarmored.	Total.
England	76	291	367
France	57	203	260
Russia	49	119	168
Germany	40	65	105
Holland	24	70	94
Spain	12	78	90
Italy	19	67	86
Turkey	15	66	81
China	7	66	73
Sweden and Norway	20	44	64
Austria	12	44	56

The table shows that, even when the present building programme is completed, the United States cannot take rank as a naval power.

The purpose for which the United States maintains a navy is not conquest, but defense. For reasons of economy and public policy the force should be as small as is consistent with this object. But it appears from the above comparison that, with all the additions authorized by the legislation of the last seven years, the country, as far as its capacity for defense is concerned, will be absolutely at the mercy of States having less than one-tenth of its population, one-thirtieth of its wealth, and one-hundredth of its area. While the element of defensive strength is thus clearly deficient, the vulnerable points open to an enemy's attack, and the interests liable at all times to injury, are numerous and important. A coast line of 13,000 miles, upon which are situated more than 20 great centers of population, wealth, and commercial activity, wholly unprotected against modern weapons, affords an inviting object of attack, with a wide range of choice as to the points to be selected. Any one of the powers named could, without serious difficulty, even after the completion of our fleet as now authorized, secure in a single raid upon our coast an amount of money sufficient to meet the expenses of a naval war; an amount one-half of which, if judiciously expended over a series of years, would be sufficient to afford this country a guarantee of perpetual peace.

The defense of the United States absolutely requires the creation of a fighting force. So far the increase has been mainly in the direction of unarmored cruisers. These vessels, while useful in deterring commercial States from aggression and as an auxiliary to secure celerity and efficiency in larger operations, do not constitute a fighting force, even when it is intended exclusively for defense. To meet the attacks of ironclads, ironclads are indispensable. To carry on even a defensive war with any hope of

success we must have armored battle-ships. The capture or destruction of two or three dozen or two or three score of merchant vessels is not going to prevent a fleet of iron-clads from shelling our cities or exacting as the price of exemption a contribution that would pay for their lost merchantmen ten times over. We must do more than this. We must have the force to raise blockades, which are almost as disastrous to commercial cities as bombardment. We must have a fleet of battle-ships that will beat off the enemy's fleet on its approach, for it is not to be tolerated that the United States, with its population, its revenue, and its trade, is to submit to attack upon the threshold of its harbors. Finally, we must be able to divert an enemy's force from our coast by threatening his own, for a war, though defensive in principle, may be conducted most effectively by being offensive in its operations.

If the country is to have a navy at all it should have one that is sufficient for the complete and ample protection of its coast in time of war. If we are to stop short of this we might better stop where we are, and abandon all claim to influence and control upon the sea. It is idle to spend our money in building small, slow-going steamers, that are unnecessary in peace and useless for war. It is little better than a repetition of the mistaken policy that prevailed in our early history of building gunboats that were laid up or sold as soon as war broke out. The country needs a navy that will exempt it from war, but the only navy that will accomplish this is a navy that can wage war.

THE NEW CRUISERS.

The new cruisers are eight in number—the *Chicago*, *Boston*, *Atlanta*, and *Dolphin*, contracted for in 1883, and the *Baltimore*, *Charleston*, *Yorktown*, and *Petrel*, contracted for in 1886 and 1887.

At the very time when the first cruisers were being designed the department took steps to supply its want of experience by the systematic acquisition of information as to naval progress abroad. The establishment of the Office of Naval Intelligence and the assignment of naval attachés to duty in Europe, both of which measures date from 1882, have been of incalculable assistance in the work of reconstruction, and it is proper to refer especially to the untiring and successful efforts of Commander F. E. Chadwick, the first attaché sent out, whose extraordinary ability and judgment during six years of difficult service in England and on the Continent have had a lasting influence upon naval development in this country. The results subsequently obtained have shown the wisdom of the policy adopted at the outset.

The net results of the Department's operations for the last seven years are more than satisfactory. The assaults made, with more audacity than judgment, upon the four experimental cruisers of 1882 have been met successfully by the performance of the vessels, and all doubts of their efficiency, if such doubts ever really existed, are laid at rest forever; while the four cruisers of 1886, assuming that the *Petrel* will eventually come up to the mark, in their advance over their predecessors, prove that both designers and constructors have kept themselves abreast of the extraordinary development in shipbuilding since the earlier cruisers were laid down, and have taken full advantage of the information and experience which they were enabled to acquire through the measures adopted at that time by the Navy Department.

ARMORED BATTLE-SHIPS.

To stop now in the work of reconstruction is to abandon everything we have gained. We have proved that at a time when war-ship construction had seemed almost a lost art in this country, American mechanics could create it anew and place the United States where it was 70 years ago, when the vessels of its navy were the best of their class afloat. We have fostered and developed a branch of industry in America which may, if kept up, attract to itself no inconsiderable share of the profits that now go to shipbuilders abroad. We have secured for our navy a certain number of excellent and useful vessels of the unprotected cruiser type at a fair and reasonable cost. We have thus laid a solid foundation. But we must not for a moment deceive ourselves by supposing that we have an effective navy. We have two distinct and widely separated ocean frontiers to protect, and there is only one way in which they can be protected—namely, by two separate fleets of armored battle-ships, with coast defense ships suitably distributed to cover the most exposed localities.

Of the great cities on the Atlantic, and of the long stretch of unprotected coast on the Gulf, from Key West to the Rio Grande, which is faced by the territorial possessions of a multitude of foreign States, it is hardly necessary to speak at length. On the Pacific Coast there are large and growing interests of vital importance, not only to that immediate neighborhood, but to the whole country, throughout its length and breadth. Among the enterprising and rapidly-growing cities which form the bulwarks of our commercial prosperity in that quarter, there are some, like Tacoma and Seattle, which it is physically impossible to protect by any land fortifications. To abandon these cities, defensible only by the navy, to the possible attacks of an enemy, and to subject to needless risk this coast and the vast region which it borders—a region second in importance to no other part of the United States—is to be guilty of an almost criminal negligence.

The necessities of our vulnerable position, therefore, demand the immediate creation of two fleets of battle-ships, of which eight should be assigned to the Pacific and 12 to the Atlantic and Gulf. They must be the best of their class in four leading characteristics—armament, armor, structural strength, and speed. The last is nearly as essential to the battle-ship as it is to the cruiser. It may safely be assumed that, other things being equal, the battle-ship of the highest speed will, as a rule, be the victor in action, for she can choose her position and keep the enemy at a disadvantage. Not only must the speed of our battle-ships be high, but it must be uniformly high, for the speed of the fleet is regulated by that of the slowest vessel.

In addition to the battle-ships, the situation of the country requires at least 20 vessels for coast and harbor defense. These vessels, although restricted in their range of effectiveness, are necessary components of a naval force which has a sea-coast to defend. Their employment as floating fortresses requires that they should have a powerful battery and the heaviest of armor, combined with moderate draft. At the present time eight vessels of this type are under construction, five of which are reconstructed monitors.

The one problem now before the Government, in the matter of a naval policy, is to get these 40 vessels built at the earliest possible moment. The steps necessary to their completion—legislation, design, and construction—cannot take less than five years in the case of each one. Unless the existing yards, public and private, are enlarged and restocked with plant, not more than eight could be built at one time, and the construction of the others would have to wait for the launching of the first. Using the utmost promptness, the ships most essential to efficient protection could not be supplied in less than 12 or 15 years.

It is, therefore, recommended that the construction of eight armored vessels be authorized at the coming session, and that they be of the type of battle-ships rather than of coast-defense ships; the former being more generally serviceable, and there being only three of them now in process of construction as against eight of the latter.

FAST CRUISERS.

In reference to fast cruisers, all modern experience goes to show that they are essential adjuncts of an armored fleet, and the proportion of three cruisers to one battle-ship is believed to be sound and reasonable. This would make the future navy consist of 20 battle-ships, 20 coast-defense ships, and 60 cruisers, or 100 vessels in all, which is believed to be a moderate estimate of the proper strength of the fleet. Of the 60 cruisers required, 31 are now built or authorized. For an increase in the number of cruisers, considered simply as auxiliaries to the fighting force of battle-ships, we may wisely wait until the latter are in process of construction. . . . . .

The naval policy of the United States cannot neglect to take account of the fleets of fast cruisers which foreign States maintain under the guise of passenger and mer-

chant steamers. They constitute an auxiliary navy, and must be reckoned as a part of the naval force of the governments maintaining them. It is difficult to imagine a more effective commerce destroyer than the steamship *City of Paris*, armed with a battery of rapid-firing guns. She can steam over 21 knots an hour, and can average 19.9 knots from land to land across the Atlantic. No man-of-war could overtake her; no merchantman could escape her. A fleet of such cruisers would sweep an enemy's commerce from the ocean. This fact is well understood in Europe, and States that are unprovided with a convertible merchant fleet are preparing to meet the possible emergency by partly-protected cruisers that are substantially as fast as the *City of Paris*. Of this type the *Piemonte* is the latest development, and others equally fast are now building.

Our deficiency should be supplied either by a line of fast merchantmen, constructed with special reference to use in time of war, which will enable the Government to avail itself of their services at critical moments, or we should build a fleet of at least five first-class cruisers of the very highest rate of speed, certainly not less than 22 knots. The displacement of these vessels should not be less than 4,000 tons. Even such a fleet will not supply the want of swift merchant steamers for coaling and transport service. Colliers and transports must alike be fast, for they cannot fight; and the collier can take no chances of capture, for she carries the life of the fleet.

In determining the size of the smaller type of cruisers, one point is settled: All steel cruisers must be large enough to admit of a double bottom. A vessel like the *Yorktown*, which has but ⅜ in. of steel on her bottom, could hardly escape sinking if she touched a rock, no matter how lightly. Such a ship must not strike. She cannot run any of the risks which the old-fashioned ships used to run every day with comparative safety, for a steel bottom will be penetrated where a wooden one would be merely scarred. Besides the *Yorktown* we have the *Concord*, the *Bennington*, and the three 2,000-ton cruisers (Nos. 9, 10 and 11), which are marked by this defect. It is not well to add to the number.

In reference to the gunboat class, any large increase in it must be condemned. This class is now represented by the *Petrel* and the two 1,000-ton vessels (gunboats Nos. 5 and 6). To make any considerable addition to it is consuming the revenues of the Government without any proportionate benefit. It is chasing the shadow and losing the substance. Such vessels add nothing to the real strength of a naval force. A cruiser to be useful must be fast enough to overtake any merchantman and to escape from any more powerful ship of war. These vessels have neither the strength to fight nor the speed to run away. A limited number of 1,000-ton vessels can be utilized in certain special kinds of service on foreign stations, and for this particular purpose it is recommended that three such vessels be constructed. Any larger increase at the present time would be injudicious and wasteful.

TORPEDO BOATS.

Apart from the want of battle-ships the most marked defect of the present fleet is in torpedo boats. The number of these boats owned by 15 foreign States is as follows:

Country.	Torpedo Boats.
England	207
France	191
Russia	138
Italy	128
Germany	98
Austria	60
Greece	51
Turkey	29
China	26
Denmark	22
Japan	21
Sweden and Norway	19
Holland	16
Spain	15
Brazil	15

The United States has one such boat under construction. This branch of defense cannot safely be neglected any longer. It is high time that steps should be taken to supply these essential constitutents of a naval force. I therefore recommend that the construction of at least five torpedo boats of the first and second classes, in suitable proportions, be authorized, as a beginning, at the coming session of Congress.

NAVAL RESERVE.

The question of the creation of a naval reserve demands the early attention of Congress. This reserve should be composed of ships, officers, and seamen. The numerical strength of our Army is not measured by the standing force, but by the trained militia behind it. The same should be true of the Navy. The necessity is even greater in this branch of the service, because a naval militia must have a special training to render it efficient in case of emergency, and it must be drawn from a limited portion of the population.

The subject has already received considerable attention, both in Congress and in the State Legislatures. Congress has as yet failed to pass any law on the subject, but the Legislatures of several States, taking the initiative, have made arrangements for the creation of a naval militia. In so far as these measures require the co-operation of the United States Government, I am heartily in favor of giving it. Where stationary vessels are desired for purposes of gunnery training, I recommend that the Department be authorized to furnish such vessels as are now laid up, unfit for sea service, to States making provision for a naval militia, upon their request. Authority should also be given for the issue of arms, and such legislation should be adopted by Congress as is necessary to give the new system vigor and efficiency.

NAVY YARDS.

On the broad question which arose in the case of the two 3,000-ton cruisers of the comparative advantages of the two systems of naval construction, the first in the Government yards, and the second by contract with private firms, the department is firmly of the opinion that the latter is the best method. It may reasonably be expected that as shipbuilding in America is gradually improved and cheapened, additional private business will be attracted to these growing establishments, until in time the world's market for ships will be divided between this country and Europe.

All these advantages are lost by a policy that confines the construction of vessels exclusively to the navy yards. Still it is advisable that the navy should build some of its ships. While the great majority of our new vessels should be constructed by private builders, the Government yards should also be utilized to a limited extent.

The only naval stations now in use as construction yards are Brooklyn, Norfolk, Mare Island, and Portsmouth, the last for wooden vessels only. The other navy yards were closed, as far as construction and repair were concerned, by order of the Secretary, June 23, 1883, under the provisions of the act of August 5, 1882.

The department having taken this action in pursuance of law, the yards referred to must remain closed until the law shall reopen them. At present there are building sites for eight ships at Brooklyn and Norfolk, and for three at Mare Island. Of the former five are now occupied. Provision has been made for supplying these yards with a working plant, which is now in part delivered. A further appropriation of $50,000 is required for tools at Brooklyn. The three construction yards will then have a working outfit. If additional facilities are needed to hasten the construction of the Navy, they may be provided either at Boston or League Island, each of which presents considerable advantages of situation.

At the Boston Navy Yard a modern plant for building steel vessels sufficient for work on an extensive scale can be set up at moderate cost. The League Island Yard has remained since its transfer to the Navy Department largely in an undeveloped state. It has fresh water in which to lay up iron and steel ships. In this last respect it stands alone, and this consideration is of itself sufficient to warrant its gradual improvement. The yard should,

therefore, be put in such order as to make it available at least for purposes of repair.

The suggestion that the naval station at Port Royal, S. C., be provided with a dry dock and other necessary facilities for docking vessels is heartily approved. The objects of a navy yard are threefold: it may be a construction yard, a repair yard, or a naval station, or all combined. For a new construction yard the Navy Department has no use. A repair yard in the Northwest will be necessary at some future time, and the time is not very far off. Vessels in those waters must not be under the necessity of going 2,000 miles to San Francisco and back to clean their bottoms or to have slight repairs made. The site for such a yard is unquestionably in Puget Sound, which has all the advantages of favorable position, great extent of navigable waters, freedom from dangers and from obstruction by ice, a temperate climate, a promise of extraordinary development, and great natural resources in coal, iron, and timber. A naval station there is needed now.

ORDNANCE.

The number of high-power steel cannon for the Navy completed to date includes 2 5-in., 48 6-in., 8 8-in., and 3 10-in. During the past year 21 6-in. guns have been finished at the Washington Navy Yard, three at the West Point Foundry, and three at the South Boston Iron Works. Besides these nine guns are in course of construction.

APPROPRIATIONS.

The estimates of the Department for the requirements of the ensuing year are $25,599,254. These include $16,212,754 for the maintenance, equipment, repairs, etc., and $9,386,500 for increase of the Navy, the latter amount to be distributed as follows: To the Bureau of Construction and Repair (new ships), $4,000,000; to the Bureau of Steam Engineering (new engines), $1,120,000; to the Bureau of Ordnance, $3,971,500 for new guns, $145,000 for the gun plant at the Washington Navy Yard, and $150,000 for the submarine torpedo-boat.

NAMES FOR NEW SHIPS.

It is recommended that the following rule be adopted for the naming of vessels: Battle-ships, after the States of the Union; cruisers, after the cities; coast defenders, armored, after important events or names connected with the history of the United States; coast defenders, unarmored, after rivers of the Union. Vessels of special classes should be given names appropriate to the service for which they are intended.

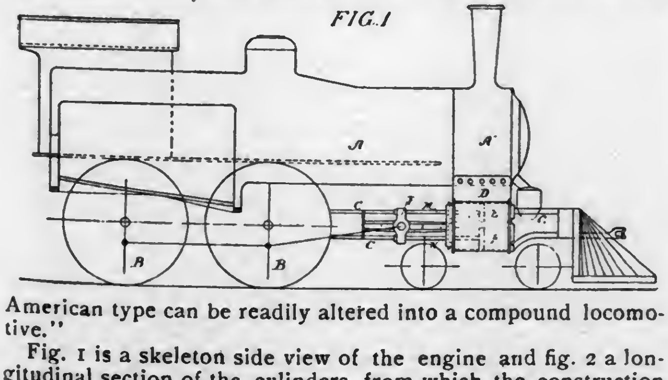
Recent Patents.

I.—COMPOUND LOCOMOTIVE.

MR. SAMUEL M. VAUCLAIN, of the Baldwin Locomotive Works, has taken out two patents: one for compound locomotives and the other for a valve for that class of engines. The compound locomotive, which was recently built at the Baldwin Works, and which has been in service on the Baltimore & Ohio Railroad, is covered by these patents.

The object of the first patent, as described by the inventor, is "to construct a locomotive-engine in which both the high and the low-pressure cylinders are on the same side of the locomotive, side by side, and connected to a common cross-head (as shown in figs. 1 and 2), so that an equal amount of power is delivered to each side of the engine; a further object being to so construct the parts that a locomotive of the single-acting

FIG. 1



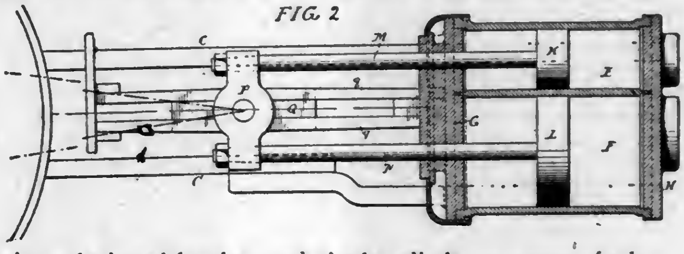
American type can be readily altered into a compound locomotive."

Fig. 1 is a skeleton side view of the engine and fig. 2 a longitudinal section of the cylinders, from which the construction will be readily understood.

The principal claim in this patent is the following:

"The within-described compound cylinder structure for locomotives, said compound structure comprising a portion on the outer side of the engine-frame and a portion on the inner side of said frame, the portion on the outer side containing the high and low-pressure cylinders, situated side by side, and the valve-chest structure for said cylinders, and the portion on the inner side containing the inlet and exhaust passages, which extend up to the smoke-box, so that the structure is capable of

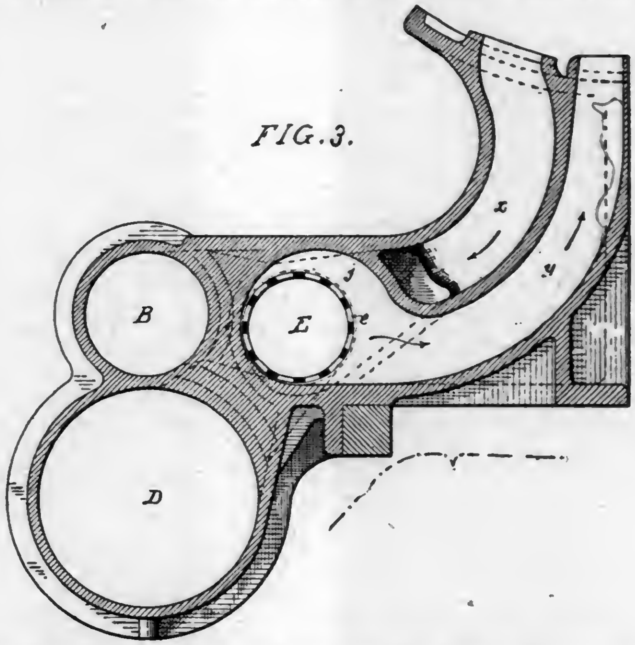
FIG. 2



being substituted for the usual single-cylinder structure of a locomotive without change of the adjacent structure, substantially as specified."

The object of the second invention, which is covered by the second patent, is to provide a compound engine with a single valve common to both the high and low-pressure cylinders, the

FIG. 3.

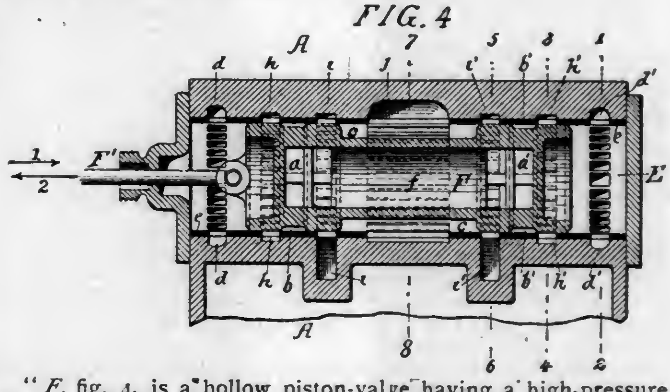


valve having been especially designed for use in connection with compound locomotive-engines, but being applicable to stationary or marine engines as well.

Fig. 3 is a transverse section through the cylinders, steam-chest and bed-casting, and fig. 4 a longitudinal section of the valve, which is thus described by the inventor:

"In the valve-chest *E* is a bushing *e*, slotted or perforated at the inlet and outlet ports, as shown, to permit the steam to enter and exhaust from the valve-chest.

FIG. 4



"*F*, fig. 4, is a hollow piston-valve having a high-pressure exhaust-passage *f* extending between openings *a a'* in said valve, said openings communicating with external grooves *b b'* in the periphery of the valve. The valve is also grooved externally at the center *c*, the grooves forming passages for the steam, as described hereinafter. The steam-supply ports *d d'*

communicate with the steam-passage *x*, fig. 3, these ports being situated at the extremes of the valve-chest, as shown in fig. 4.

"Ports *h h'* communicate with the opposite ends of the high-pressure cylinder, and serve alternately as induction and eduction ports for said high-pressure cylinder, *i i'* being the corresponding ports for the low-pressure cylinder, and *j* is the final exhaust-port communicating with the exhaust-passage *y*, as shown in fig. 3.

"A valve-rod *F'* is connected to the valve *F*, and passes through a stuffing-box in the head of the valve-chamber, as shown in fig. 4, for connection to any suitable valve-gear. When the valve is moved in the direction of the arrow 1, fig. 4, so as to uncover the port *h*, the port *h'* is in communication with the groove *b'*, the port *i'* with the groove *c*, and the port *i* with the groove *b* of the valve; hence steam passes from the supply-port *d* through the port *h* to the rear end of the high-pressure cylinder, while steam is exhausted from the front end of the said cylinder through the port *h'*, through the groove *b'*, port *a'*, passage *f*, port *a*, and groove *b* of the valve, and through the port *i* to the rear end of the low-pressure cylinder *D*, the steam exhausting from the front end of the low-pressure cylinder through the port *i'*, groove *c*, and port *j* to the exhaust-passage *y*.

"When the valve is moved in the direction of the arrow 2, high-pressure steam from the supply-port *d'* passes through the port *h'* to the front end of the high-pressure cylinder, steam passing from the rear end of the same through the port *h*, valve, and port *i'* to the front end of the low-pressure cylinder, and steam escaping from the latter through the port *i*, groove *c*, and port *j* to the exhaust.

"By the above-described means I am enabled with a single valve to control the admission of steam into the high and low-pressure cylinders, and by making the valve hollow or with a passage through it I am enabled to restrict the size of the valve and chest, and provide comparatively straight and short passages for the steam."

II.—CAR-COUPLING.

Mr. Benjamin Follansbee, of Allegheny, Pa., has patented the ingenious car-coupling shown in figs. 5 and 6; fig. 5 being a longitudinal section, and fig. 6 a plan of two draw-bars, with the coupling apparatus attached. The following is the inventor's description of his invention:

"In the drawings 6 7, 6' 7' are bell-crank levers, whose elbows are situated between the draw-bar straps and are keyed to the shafts 4, as shown in fig. 2. To the end of one arm 4' of each bell-crank lever is pivotally connected a coupling-pin 8, and to the end of the other arm 6 is similarly connected a

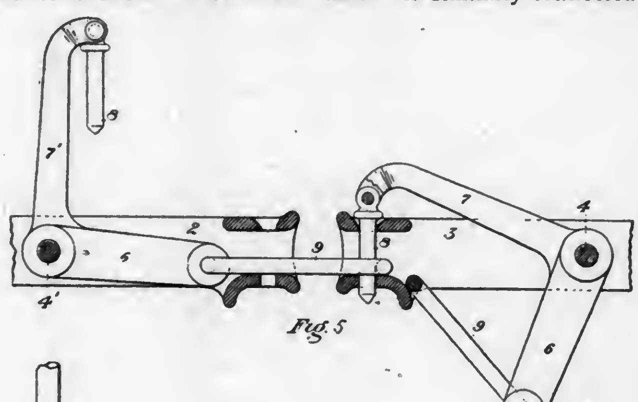


Fig. 5

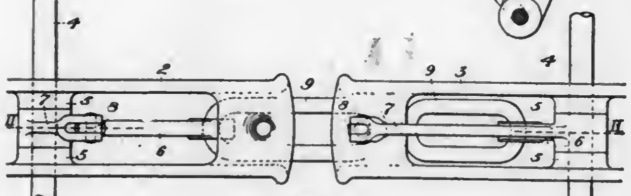


Fig. 6

coupling-link 9, which is adapted to project through the head of the draw-bar when either of the arms 6 or 6' is in a horizontal or nearly horizontal position, in which 6' is represented, and to be retracted when either arm is in a downwardly-extending position, in which 6 is shown.

"The manner of coupling two cars provided with my improvement is clearly shown in fig. 5. The arm 7' of the bell-crank of one draw-bar is elevated, and the arm 6' is therefore brought to a horizontal position, so as to project its coupling-link 9' through the draw-head and into the draw-head of the next car. The bell-crank lever of the other coupling is put into such position that the arm 7 is nearly horizontal, and the arm 6 extends downwardly, thus bringing the coupling-pin 8 through the pin-holes in the draw-head 3 and through the coupling-link of the draw-bar 2, and retracting the coupling-link 9 of the draw-bar 3 out of the path of the other coupling-link, the end of the link still, however, resting on and being supported by the head of the draw-bar.

"It is obvious that in coupling the cars the link of either car may be projected and the other link retracted, and that my improved coupler may be used in connecting the couplers of the ordinary link-and-pin form.

"For the purpose of operating the bell-crank levers of the couplers without making it necessary to enter the space between the cars, the shafts 4 and 4' are extended to the outside of the cars, and their ends are provided with cranks by which the shafts may be turned and the bell-crank levers may be put in the proper position to couple or uncouple the cars to which they are attached."

III.—PRESSURE-REGULATOR.

Mr. James F. McElroy, of Lansing, Mich., has patented a pressure-regulator which he says is particularly adapted for use in connection with steam-heating apparatus for railroad cars. It is shown in section by fig. 7, and is described as follows:

"The casing consists of a tubular portion *A*, provided at opposite ends with suitable pipe-connections *B* and *C*, and of a

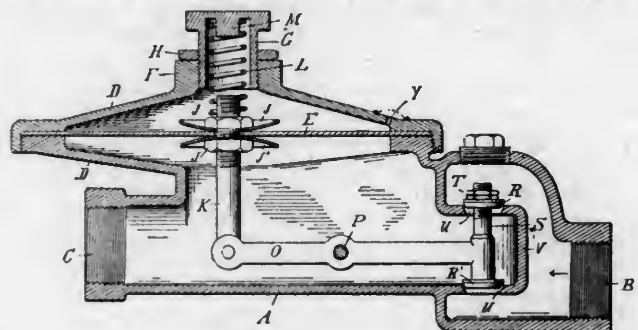


Fig. 7

diaphragm-valve casing *D* and *D'*, in close proximity to the top of the tubular casing and connecting therewith. The upper portion or cover *D'* of this casing is connected with the lower portion *D*, with the edge of the diaphragm-disk *E* clamped between. The cover *D'* is provided with an upwardly-projecting boss *F*, which is screw-threaded to receive the hollow adjustment-nut *G*, which is locked in position by a jam-nut *H*. In the center of the diaphragm is secured by means of the nuts and washers *J* and *J'* the screw-threaded stem *K*. The washers are made of spherical shape, with corresponding spherical faces on the nuts, whereby the stem is firmly secured to the diaphragm without reducing the elastic area of the same.

"*L* is a regulating-spring interposed between the adjusting-nut and the diaphragm. The stem *K* projects with its lower end into the tubular casing *A*, and is there connected to one end of the lever *O*. This lever *O* is fulcrumed at *P*.

"*R* and *R'* are two valve-disks secured upon a common stem *S*, which is placed at right angles to the lever *O* and secured thereto, by being formed integrally therewith. The lower valve disk *R'* may also be formed integrally therewith; but the upper valve-disk *R* is adjustably secured to the stem and provided with suitable lock-nuts *T*.

"*U* and *U'* are the valve-ports, controlled by the valve-disks *R* and *R'*, and these valve-ports are formed by a partition *V*, which divides the high-pressure side from the low-pressure side of the device. Below the valve *R'* and above the valve *R* the casing *A* is enlarged to form a free access of the steam to the valve-disks, and a screw-plug is secured in the casing above the valve *R* to afford access to the valve for the purpose of adjustment.

"In the absence of any steam-pressure the adjustment of the regulating-spring *L* is such as to keep the valve-ports *U* and *U'* normally open, and if steam is admitted through the inlet *B* it is free to enter through such ports into the low-pressure side of the device, which opens out underneath the diaphragm, and, acting against the same by its pressure, will distend the diaphragm against the action of the regulating-spring, and thereby, through its connection with the valve-stem *K*, the lever *O*, and valve-stem *S*, will absolutely control the position of the valves *R* and *R'* in relation to the ports, and should the pressure upon the diaphragm exceed a certain limit, according to the adjustment of the spring *L*, both valves will be closed upon their seats until the pressure on the diaphragm is relieved. Thus it will be seen that the amount of steam admitted into the low-pressure side depends entirely upon the tension of the diaphragm through the regulating-nut *G*, and any desired fixed

pressure, therefore, may be maintained on the low-pressure side, no matter what the pressure of steam is on the high-pressure side.

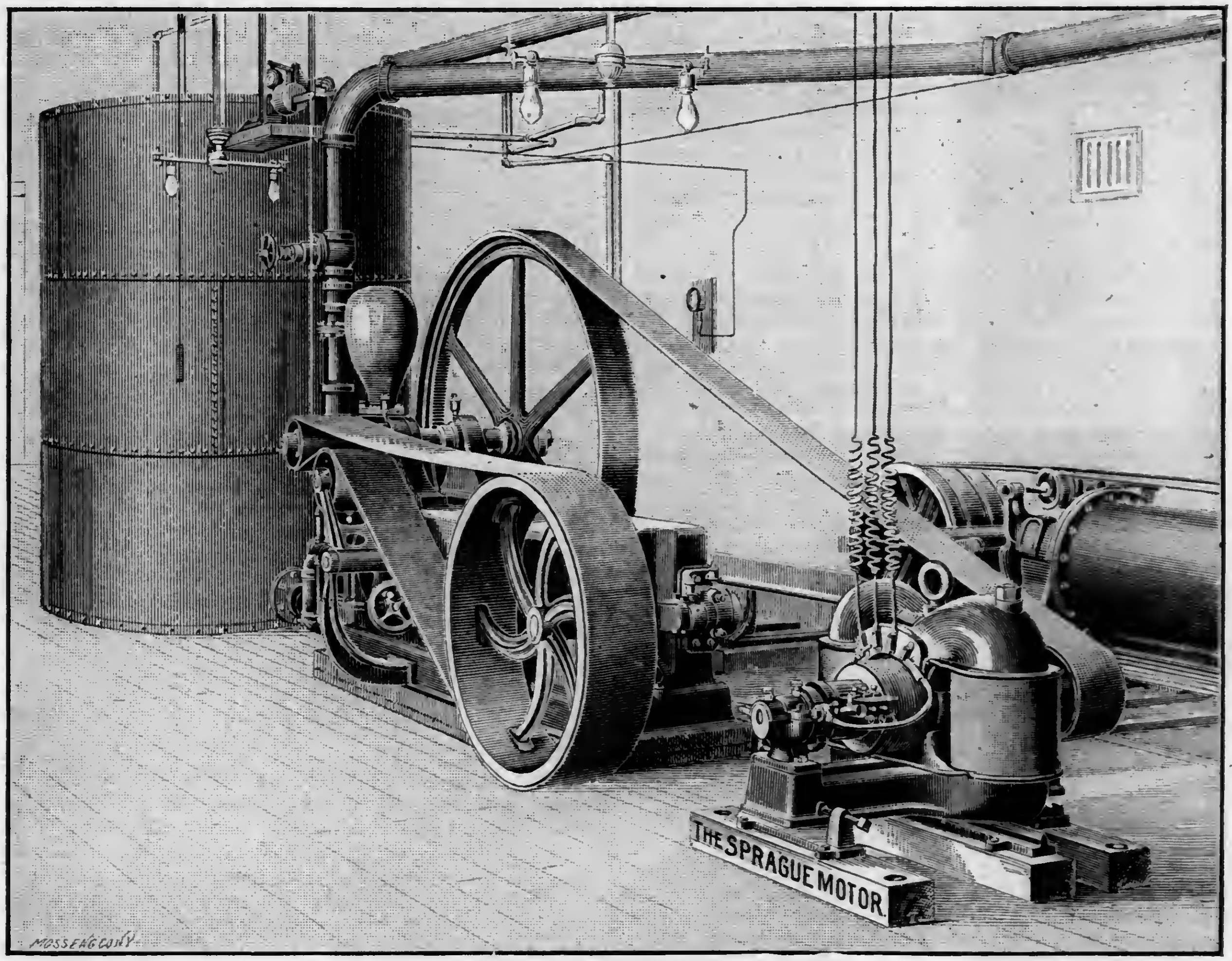
"The valves *R* and *R'* are balanced both on their high and low-pressure sides by making them both of the same area. To prevent too quick a motion of the diaphragm, I provide a small vent or pin-hole *Y*, through the cover *D'*, which is covered with a screen to prevent dirt from entering."

An Electric Elevator Installation.

THE accompanying illustration shows a view of a recent installation of excellent design for an hydraulic elevator, which has been put in the building of the United Security, Trust & Safe Deposit Company in Philadelphia, by the Otis Elevator Company, of Yonkers, N. Y., and by Chadbourne, Hazleton & Company, of Philadelphia, who are agents in Pennsylvania for the Sprague Electric Railway & Motor Company of New York. When the elevator was first put in a gas-engine was used to supply the necessary power, but it did not prove satisfactory, and the Sprague motor was substituted. This is now giving perfect satisfaction, and is considered to be one of the best-running elevator plants in Philadelphia.

A notable point about the whole arrangement is that the minimum of space has been taken for every part of this installation. The pump was manufactured specially for this plant, and the arrangement for reduction of speed between the armature shaft and the pump is made in the compact manner shown. The motor operates the pump against the pressure in the tank, there being no overflow, and when the maximum pressure is reached the motor runs empty, automatically cutting down the amount of electric current taken from the line, so that only sufficient current is used to supply the energy necessary to keep the motor in revolution.

The illustration is made from a photograph taken directly from the plant, and shows the details of the installation very completely.



ELEVATOR WITH SPRAGUE ELECTRIC MOTOR.

Manufactures.

Manufacturing Notes.

THE steel plates and shapes for the armored ships *Maine* and *Texas*, now under construction at the New York and Norfolk Navy Yards, are to be furnished by Carnegie Brothers & Company, limited, and the Linden Steel Works in Pittsburgh, the contracts having been awarded to those firms.

AT the recent Exhibition in Pittsburgh a remarkable display of aluminum was made by the Pittsburgh Reduction Company, the exhibit including probably the largest amount of that metal ever shown at once. It included a number of small ingots weighing 5 lbs. each and aggregating in all about one ton in weight; one large ingot weighing 150 lbs. and a number of articles manufactured of the metal. The Company has been very successful in its production of aluminum so far, and the price of this metal in workable form has already fallen about one-half.

THE Bethlehem Iron Works at Bethlehem, Pa., have a contract for the steel to be used for the new 3,000-ton cruisers, which are to be built in the New York and Norfolk Navy Yards.

THE Bucyrus Foundry & Manufacturing Company, Bucyrus, O., has just taken a contract to build five large steam-shovels for the Northern Pacific Railroad. This is believed to be the largest order for steam-shovels ever placed at one time, and makes 11 of these machines sold by these works to the Northern Pacific Railroad Company. During the present year also, the Lake Shore & Michigan Southern has bought four large Bucyrus shovels. Other orders on hand include three large land-dredges to be used in constructing a canal at Bear Lake, Utah; three large steam-shovels to go to the iron-ore district on Lake Superior, to be used for handling iron ore from the stock piles; 13 steam-shovels for spring delivery, and several large dredges. The works are running overtime to fill orders.

THE Schoen Manufacturing Company, of Philadelphia, has increased its capital stock to $300,000, and is now engaged in building new works in Pittsburgh adjoining those of the Oliver Iron & Steel Company. The buildings are of iron and fire-proof, and will contain a complete forging plant on the hydraulic system, with a capacity for turning out from 40 to 50 tons per day. The Company's chief business is in the manufacture of articles in pressed steel for railroad equipment, such as center plates, stake pockets, etc. The President of the Company is C. T. Schoen, of Philadelphia, and the Vice-President is Henry W. Oliver, of Pittsburgh.

THE Illinois Steel Company has decided to add a new furnace for the manufacture of basic steel to its plant at Joliet, and four furnaces and one plate mill to its plant at South Chicago, thus largely increasing the capacity of its works.

THE Cedar Point Furnace, Port Henry, N. Y., has gone into blast after a rest of two years. This furnace uses ore from the mines of Witherbees, Sherman & Company at Mineville, N. Y.

THE Pittsburgh Steel Casting Company is about to make an extensive addition to its equipment. Work will begin at once on a Bessemer steel plant in connection with their foundry, so that they can make Bessemer steel castings up to 16,000 lbs. in weight. An eight-ton converter will be erected, and the new plant will probably be in operation early in April.

THE North Carolina Steel & Iron Company has been organized at Salisbury, N. C., and will begin operations by building a blast furnace of 150 tons daily capacity at Greensboro, N. C. This will be followed by a Bessemer steel plant and rolling mill. The Company has secured lands near Greensboro, where magnetic iron ore is found in large quantities. Among the incorporators are George S. Scott of New York, President of the Richmond & Danville Railroad Company, and James G. Pace of Richmond, Va.

THE Pond Engineering Company, St. Louis, Mo., has the contract to furnish two Armington & Sims engines of 100 H. P. each to the Electric Street Railroad Company at Vancouver, B. C.; also an engine of the same power to the Electric Light Company at Dixon, Ill. This company has recently shipped four 80 H. P. boilers, two boiler feed-pumps, two Blake condensers to Mexico; also an Armington & Sims engine of 50 H. P. to the water-works at Holden, Mo. The Company has recently sold a number of small vertical boilers in the Southwest. Other recent contracts of this Company include a Blake mining pump of large size to the Shotwell Mining Company; a 100 H. P. heater to the Gay Building, St. Louis, and a complete 80 H. P. plant for Murphysboro, Ill., including an Armington & Sims engine, boiler, heater, pump, etc.; also a 200 H. P. compound condensing Armington & Sims engine for the Thompson-Houston Company, stationed in Omaha, Neb.

DURING October the Westinghouse Machine Company in Pittsburgh sold 35 junior engines corrugating 1.095 H. P.; 32 standard engines of 1,395 H. P.; 43 compound engines of 3,545 H. P., making a total of 110 engines of 6,035 H. P. in all.

THE firm of Forsythe & Company, of New York, has succeeded to the business formerly conducted by Herrick & Bergen and the Gardner Company, and now manufactures the perforated veneer seats, panelings, head linings, etc., which was so well known and so widely used in the Gardner patent.

THE Parsons Block, Switch & Frog Company of 29 Broadway, New York, has delivered one of its frogs and switches to the Superintendent of the Brooklyn Bridge, and they have been put in operation upon a cross over on the Brooklyn end of the bridge. The switch and frog will there receive a very thorough test, as more than 4,000 cars a day pass over this frog and switch, the traffic being almost constant.

Cars.

THE Consolidated Car Heating Company, Albany, N. Y., has absorbed the Automatic Car Coupler Heating Company of Detroit, Mich., and has acquired the ownership of the "Peerless" coupler and other valuable appliances for steam heating.

THE Ohio Falls Car Company, Jeffersonville, Ind., has recently taken the contract to build 22 passenger cars and 1,200 freight cars for the Central Railroad of Georgia. These works are now very busy and are turning out 2 passenger cars a week and 22 freight cars a day.

THE Central Railway Supply & Construction Company has been organized at Indianapolis, Ind., to manufacture and deal in railroad equipment. The capital stock is $350,000.

THE Michigan Car Company, Detroit, Mich., is building 300 box cars for the Flint & Père Marquette Railroad.

THE Haskell & Barker Car Works at Michigan City, Ind., have taken a contract to build 500 coal cars for the Columbus, Hocking Valley & Toledo Railroad.

Marine Engineering.

THE Sheridan Iron Company of Champlain, N. Y., has taken the contract to build a boat for the steam ferry at Port Henry, N. Y. The boat will be a double-screw vessel, 75 ft. long and 30 ft. beam, modeled after the new ferry-boat *Bergen*. She will have a triple-expansion engine of 75 H.P., and is to make not less than eight miles an hour.

THE new steamer *Orizaba* was recently launched from the Roach Yard at Chester, Pa., for the New York & Cuba Mail Steamship Company. The *Orizaba* is of steel 340 ft. 6 in. long over all, 43 ft. 3 in. beam, and 22 ft. 10 in. depth of hold. She will have large accommhdations for passengers. The engines are of the triple-expansion type with cylinders 28 in., 44 in., and 70 in. diameter and 48 in. stroke. The screw is of brass 15 ft. 6 in. in diameter. The boilers are cylindrical, 12 ft. in diameter and 11 ft. 6 in. long, and will carry a working pressure of 160 lbs. Another vessel of the same size is to be begun immediately in the same yard.

THE new steamer *Charlotte* for the Baltimore, Chesapeake & Richmond Steamship Company was recently completed in the yard of Neafie & Levy in Philadelphia. The vessel is of iron, 243 ft. 4 in. long over all, 24 ft. beam, and 24 ft. in depth. She has a triple-expansion engine with cylinders 21 in., 31 in., and 55 in. in diameter and 36 in. stroke; with a four-bladed propeller 12 ft. diameter and 14 ft. pitch. There are two Scotch boilers 13 ft. diameter and 14 ft. long, each having three corrugated furnaces 44 in. diameter and 11 ft. long, furnished by the Continental Iron Works. The boilers will carry 160 lbs. working pressure. The *Charlotte* is to run between Baltimore and West Point.

THE hydraulic steamer *Evolution*, built on the plans of Dr. W. M. Jackson, of New York, was recently launched at the yard of James Lennox at Brooklyn. This vessel is to be propelled on the water-jet system, and her machinery consists of a Roberts tubular boiler and of a duplex compound Worthington steam pump. Working at its full capacity this pumping engine will deliver 1,000 gals. of water a minute through a nozzle $\frac{15}{16}$ in. in diameter, and this jet of water is expected to propel the vessel. A number of experiments have been made before, both in this country and in Europe, with the water-jet system of propulsion, and the result of this new trial will be awaited with some interest.

Bridges.

THE Central Bridge Works at Peterboro, Ont., have secured contracts for two new iron bridges on the Grand Trunk Railway.

The contract for the bridge over the Kaw River, Kansas City, Mo., has been awarded to the Youngstown Bridge Company, Youngstown, O. The bridge will have three spans, 200 ft. long each and one 175 ft. long, and will have a roadway 20 ft. wide.

THE St. Louis Bridge & Iron Company have recently taken contracts for three iron highway bridges in Illinois, two in Kansas, and one in Missouri.

THE Potomac Bridge Works have purchased property in Frederick, Md., and will put up works there for building iron bridges. H. G. Welty is at the head of the enterprise.

THE Keystone Bridge Company, Pittsburgh, Pa., is at work on a bridge over the Ohio River at Brunot's Island. The bridge will be a little over 3,000 ft. long in 16 spans.

THE Groton Bridge Works, Groton, N. Y., are building an iron bridge of 153 ft. span over the Cattaraugus River at Gowanda, N. Y.

THE bridge over the Lehigh River at Easton, Pa., on the Central Railroad of New Jersey, is to be replaced by a new double-track bridge having two through spans of 160 ft. each and one through skew-span of 175 ft. The new bridge will be built by the Phœnix Bridge Company.

THE Easton & Northern Railroad has let contracts for two

through spans of 112 ft. each and two lattice girder spans of 95 ft. each to the Edge Moor Bridge Works; also for a number of small girder bridges, which will be built by the Union Bridge Company at its Athens shops.

THE Lehigh Valley Company has contracted with the Edge Moor Bridge Works for the bridges on its new extension to Jersey City, as follows: At Roselle one double-track span of 165 ft. across the Central Railroad of New Jersey; at Newark the bridge across the Pennsylvania Railroad, with two double-track spans, one of 175 ft and one of 154 ft.

THE Phœnix Bridge Company has a contract for 2,500 tons of small iron bridges for the Western Railroad of Uruguay. Work has been begun on the material, which is to be delivered on board ship at New York by February 1.

THE contract for the great iron roof of the Madison Square Garden Building in New York has been let by the architects, Post & McCord, to the Phœnix Iron Company.

BOTH the Phœnix Iron Company and the Pencoyd Iron Company are building special plants for making eye-bars. At the former works the buildings for the annealing furnaces and the testing machine are nearly completed, and the parts of the testing machine are in the shops. This machine will have a capacity of 1,000 tons, and will break an eye-bar 9 × 3 in. in section and 60 ft. long without resetting. It is expected to exceed the machines at Athens and at the Watertown Arsenal in capacity.

THE Red Rock Bridge across the Colorado River, now under construction, will contain the largest driven pins in the country, if not in the world. These pins are 15 in. in diameter and 5 ft. 8 in. long, and weigh 3,900 lbs. A pilot-nut 18 in. long and a butt go with the pins for driving. The pin-holes are bored $\frac{1}{16}$ in. large to insure driving, as the pins will have to pass through 4 ft. of metal.

THE Pottstown Iron Company, Pottstown, Pa., recently put its new furnace in blast. In starting the furnace an explosion was caused by moisture, which made a great noise, but fortunately did no serious damage. The Company now has its Bessemer-basic steel plant in active operation.

Locomotives.

THE Schenectady Locomotive Works, Schenectady, N. Y., are building 10 consolidation engines with 21 × 24 in. cylinders for the Chesapeake & Ohio Railroad.

THE Brooks Locomotive Works, Dunkirk, N. Y., have recently built 10 mogul engines with 19 × 26 in. cylinders for the New York Central & Hudson River Railroad. The same works are also building for the Cleveland, Cincinnati, Chicago & St. Louis Railroad five 6-wheeled switching engines with 18 × 24 in. cylinders and 10-wheeled passenger engines with 19 × 24 in. cylinders and 62 in. drivers. The 10-wheeled pattern, by the way, seems to be growing very popular for heavy passenger service. The Brooks Works have recently shipped engines to the Chesapeake & Ohio, the Lake Erie & Western, the Toledo & Ohio Central, and several other roads, and one passenger engine to Cuba.

THE Baldwin Locomotive Works, Philadelphia, are building five freight engines for the Salt Lake & Eastern Railroad.

H. K. PORTER & COMPANY in Pittsburgh are building two light passenger engines for the Salt Lake & Eastern Railroad.

Electrical Notes.

THE West End Street Railroad Company in Boston has recently put in operation the electric cars on the Shawmut Avenue Line and on the line from Park Square to Cambridge. The Arlington and the Brighton lines of the Company have been operated by electric cars for some time. The Company, as has been already stated, purposes continuing the work until all its lines are operated by electricity.

THE Sprague Electric Railway & Motor Company, of New York, has recently closed contracts for equipping street railroads, as follows: Sioux City, Ia., Electric Railroad, 12 cars; Sherman, Tex., College Park Electric Belt Line, 5 cars; Newark, O., Electric Railroad, 1 car; Milwaukee, Wis., West Side Street Railroad, 10 cars; Nashville, Tenn., & Edgefield Railroad, 10 cars; Nashville, Tenn., South Nashville Railroad, 10 cars; Salt Lake City, Utah, Electric Railroad extension, 10 cars; Youngstown, O., Electric Railroad, 6 cars. The Company's works are now very busy on street railroad motors, and new orders and inquiries are constantly received.

Iron Production.

THE *American Manufacturer* gives a statement of the condition of the blast furnaces on December 1, and says: "In a condensed form the showing is as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	69	13,226	94	11,725
Anthracite	106	40,228	82	21,907
Bituminous	162	113,501	82	38,416
Total	337	166,955	258	71,048

"As compared with a year ago, there have been some material changes, as will be seen from the following table:

	Dec. 1, 1889.		Dec. 1, 1888.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	69	13,226	73	13,270
Anthracite	106	40,228	107	31,052
Bituminous	162	113,501	151	94,960
Total	337	166,955	331	139,282

"Adding together the capacities of the furnaces in blast for the first six months of the year and the last six months of the year, the result would indicate that there was an increased production in the last six months of the year of 7.6 per cent.

"As the production of the country in the first half of 1889 was 3,667,767 gross tons this would indicate a production of 3,946,517 in the last half of the year, which would indicate a total production for the year of 7,614,284 tons."

Shipments of iron ore from the Lake Superior Region for the season of navigation just closed have been as follows:

	1889.	1888.
Marquette	1,376,335	844,694
Escanaba	3,003,632	1,202,965
St. Ignace	54,853	107,399
Ashland, Wis	1,484,802	1,016,414
Two Harbors, Minn	816,630	450,475
Gladstone	48,250	......
Total	6,805,511	4,631,947

The gain over last season's shipments is 2,182,564 tons, and the total brings the quantity sent to market by water up to a figure that leaves no doubt that the shipments by rail will carry the output of the mines for the year above 7,000,000 tons. The year just ended has been a notable one in the history of iron mining on Lake Superior.

OBITUARY.

H. B. KITTENDORF, who died in New Haven, Conn., December 12, was for a number of years Master Mechanic of the New York, New Haven & Hartford Railroad. He retired from that position several years ago and has since been connected with the New Haven & Derby Railroad. He was 62 years old.

EDWARD N. DICKERSON, who died in Rockaway, N. Y., December 11, aged 53 years, was for many years one of the best-known patent lawyers in the country. He studied law and practised it for a time, but afterward traveled, and on his return home devoted himself to scientific and mechanical studies. His controversies with Chief Engineer Isherwood during the war, in relation to working steam expansively, will be remembered by many. After the war he returned to the bar and was engaged in many important cases, the latest being the "Bell Telephone."

THOMAS A. WALKER, who died in London recently, aged 60 years, was one of the best-known English Railroad contractors. He was for a number of years connected with Mr. Brassey, the great contractor, as an Engineer, and in that capacity built part of the Grand Trunk Railroad and the Nova Scotia Railroad, and was engaged on several Russian roads. Later he superintended the construction of a large part of the underground railroad lines in London, and had charge of other important works. At the time of his death he was contractor for the Manchester Ship Canal.

FRANKLIN B. GOWEN died suddenly in Washington, December 14, under circumstances which lead to the belief that he committed suicide, although it is possible that he might have been killed by the accidental discharge of the pistol in his own hands. Mr. Gowen was 53 years old, was born in Philadelphia, and was by profession a lawyer. He made his mark as prosecutor of Schuylkill County, Pa., when still a young man, and in 1862 he was made Counsel of the Philadelphia & Reading Railroad Company. In 1870 he was elected President of that Company and held the office until 1886, with the exception of the year 1881, when he was defeated by Mr. Frank S. Bond, and retired for a year, returning, however, to the presidency in 1882. Mr. Gowen made a high reputation as a lawyer by conducting the famous "Molly Maguire" trials, which broke up the system through which the coal mining regions of Pennsylvania had been terrorized. While President of the Reading Company he became one of the best-known men in the country, but while his administration was brilliant, it cannot be called successful, since it ended in the bankruptcy of the Company and a receivership. He conducted the first reorganization, but afterward retired from the management of the road, and has since taken no active part publicly, although he had continued to practise law. No cause can be assigned why he should have committed suicide.

PERSONALS.

ANTHONY JONES has resigned his position as Chief Engineer of the Long Island Railroad, after seven years of service with the Company.

C. C. MALLARD has been appointed Assistant Superintendent of bridges and buildings of the Southern Pacific Company's Atlantic Lines.

MAJOR E. T. D. MYERS, for a number of years past General Superintendent of the Richmond, Fredericksburg & Potomac Railroad, has been chosen President of the Company.

M. J. MCINARNA has been appointed Road and Bridge Inspector by Railroad Commissioner Cappeler of Ohio. He was recently Roadmaster of the New York, Pennsylvania & Ohio Railroad.

C. E. HENDERSON has been appointed General Manager of the Philadelphia & Reading Coal & Iron Company, with office at Pottsville, Pa. He was recently General Manager of the Ohio, Indiana & Western Railroad.

WILLIAM P. SHINN has retired from his position as Vice-President and General Manager of the New York & New England Railroad Company after three years of service in that position. Mr. Shinn's administration has been very successful.

HORACE SEE, formerly connected with Cramp & Sons in Philadelphia, has opened an office as Consulting Engineer at No. 1 Broadway, New York. Mr. See's ability and experience as a mechanical and marine engineer are well known.

E. J. BLAKE, formerly Chief Engineer of the Hannibal & St. Joseph Railroad and of the Kansas City, St. Joseph & Council Bluffs Railroad, has been appointed Chief Engineer of the Chicago, Burlington & Quincy Railroad, taking the place of GEORGE C. SMITH, who has resigned.

F. W. DEAN, the well-known mechanical engineer, announces that he is prepared to furnish designs for compound locomotives and high-pressure boilers adapted to any kind of railroad service; also designs for converting existing locomotives into compounds. Mr. Dean's office is at 27 School Street, Boston.

CLEMENS HERSCHEL has resigned his position as Engineer of the Holyoke Water Power Company, and will go to Newark, N. J., where he will have charge of the construction of new water-works. Mr. Herschel is well known as a Hydraulic Engineer, and has served as Consulting Engineer for many important enterprises. He was at one time a member of the Massachusetts Railroad Commission.

CHARLES HOWARD has been appointed General Manager of the New York & New England Railroad, succeeding Mr. William P. Shinn, who has resigned. Mr. Howard served on the old Boston, Hartford & Erie Road a number of years ago, and has since been Superintendent of the Cincinnati, Sandusky & Cleveland and of the Danville & Ohio River roads, General Manager of the Worcester, Nashua & Rochester, and Manager of the Providence & Worcester Railroad.

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers.—At the regular meeting in New York, November 20, a paper by Edmund B. Weston on the Result of Investigations Relating to Formulas for the Flow of Water in Pipes was read. A written discussion was also read by Rudolph Hering on this paper, and the paper was discussed verbally by Messrs. Brush, Freeman, Emery, and Fteley.

AT the regular meeting in New York, December 18, a paper by Franz A. Veschow on the Causes of Trade Winds was read, and was discussed by the members present.

THE 37th annual meeting of the Society will be held in New York, January 15, at 10 A.M. The annual reports and reports of the standing committees will be presented, officers elected, time and place for the annual convention considered, and other business transacted.

It is expected that the business will be completed on the first day. Arrangements for the second day, January 16, will be announced by the Local Committee.

Boston Society of Civil Engineers.—At the regular meeting in Boston, November 20, the Committee appointed to confer with the Committee of the American Society presented a report favoring some plan of union, and giving a summary of the correspondence had with the American Society.

A paper on the Freezing Process of Making Excavations in Wet Ground was read by Mr. E. S. Abbott.

New England Water-Works Association.—The regular quarterly meeting was held in Boston, December 11, with a very large attendance. The following members were elected: Elmer E. Farnham, Sharon, Mass.; John C. Haskell, Lynn, Mass.; W. H. Vaughan, Wellesley, Mass.; Charles F. Parks, William Wheeler, Boston, Mass.; John W. Ellis, Woonsocket, R. I.; William E. Davis, Sherburne, N. Y.; Samuel B. Leach, Tarrytown, N. Y.; Professor J. E. Denton, Hoboken, N. J.; H. J. Koch, Aspen, Col.; E. P. Foster, San Buenaventura, Cal.; Edward M. Boggs, San Bernardino, Cal.; C. H. Tompkins, Jr., Boisé City, Idaho.

Mr. J. R. Freeman then read a paper on experiments and practical tables relating to the Discharge of Fire-streams, and the Loss of Pressure by Friction in Hose. In this paper he argued in favor of the increase in the standard size of fire hose, and also in favor of larger water mains in districts occupied by factories and other large buildings. This paper was discussed by the members present.

Engineers' Club of Philadelphia.—At the regular meeting in Philadelphia, November 16, Mr. William B. Spence, visitor, exhibited a working model of the Rimmer Oxidizer, a filtering material, which he described, and for which he made various claims as to its utility in the purification of water by oxidation.

Mr. Spence stated that the material used is an English invention and that it is known as Magnetic Carbide of Iron. It consists of a mixture of granulated iron ore and carbon. The iron ore is said to be cleaned of all natural impurities by a patented process. It is then chemically treated at a certain temperature.

To illustrate the destruction of organic matter, sulphide of ammonia, sulphide of iron, and acetate of lead were added to water, making a compound which was almost black and of strong and unpleasant odor. After filtration it was clear, and tests seemed to fail to discover any trace of the impurities.

A mixture of copying ink and water was passed through the filter with the same results.

The entire balance of the evening was spent in making inquiries and in the discussion of this apparatus.

A REGULAR meeting was held in Philadelphia, December 7. The Committee on Highway Bridges reported no further business before it and was discharged. A Committee was appointed to arrange for a Club Reception on the anniversary of the organization. Nominations were made for officers for the ensuing year.

Mr. George Burnham, Jr., described the spirally-welded steel tubing made at East Orange, N. J., exhibiting a length of pipe 10 in. in diameter by 9 ft. 5 in. long. (The method of making this tubing was described in the JOURNAL for March, 1889, page 118.) This contribution was discussed at some length.

Mr. A. P. Brommell presented an illustrated paper upon a new system of street-car propulsion. This paper also was discussed at some length.

Franklin Institute.—The programme of lectures for the month of January is as follows:

January 6: Chemistry of Coal, by Professor F. W. Clarke.
January 10: New Applications of Photography, by John Carbutt.
January 13: A Revolution in Dyeing, by Professor R. L. Chase.
January 17: Mammoth Cave of Kentucky, by Professor W. Le Conte W. Stevens.
January 20: Electricity in Warfare, by Lieutenant Bradley A. Fiske, U. S. N.
January 24: Inheritance of Acquired Characters, by Dr. Edward D. Cope.
January 27: Color-blindness, by Dr. W. Thompson.
January 31: Sketches of Germany, by C. J. Hexamer.

Civil Engineers' Club of Cleveland.—At the semi-monthly meeting, November 26, the discussion of the subject presented by Mr. Bartol at the last meeting—Recent Developments in Steel and Iron Manufacture—was resumed.

It was pointed out that the difference between iron and machinery steel of to-day is due to the difference in the mode of manufacture rather than to chemical composition. The steel having been melted and cast into ingots was in a homogeneous state; while iron is made by puddling, which is really the welding together of the particles into a spongy mass, which is compacted by hammering or rolling.

The relative merits of iron and steel for structural purposes were discussed, and the advantages of soft steel dwelt on. It was claimed that most of the trouble with steel had come from using inferior grades. In order to compare tests of steel it is necessary that the test-pieces have the same length of test-section. For this reason it is very desirable that a standard length of test-piece be adopted by engineers. Most specifications require 8 in. of section, but it was stated on good authority that 4 in. or four times the breadth was used in steel works and considered to possess all requirements for a standard length of section, besides being less expensive than the 8 in.

Mr. W. B. Wood then read a paper on Facts and Speculations Regarding the Planet Mars, which was followed by a discussion, its canals and satellites being dwelt on. President Warner's paper on Astronomical Photography, which followed, was illustrated by an enlarged photograph of the moon taken by the Lick Telescope. In the discussion the process was described by which the heavens are being photographed and mapped by the co-operation of the astronomers.

At the regular monthly meeting, December 10, Herman Pool, W. B. Cleveland, and Royal Gurley were elected active members; Hiram A. Tucker, associate member.

Dr. Mabery, Professor of Chemistry, gave a lecture on Development of the Color Industry from Coal-tar Products, which was illustrated by specimens of colors and experiments. The Egyptians used indigo for coloring in prehistoric times. The best coloring, however, is got from indigo made from coal-tar products. So great is the variety of dyes made from the products of coal-tar that now every color and shade is made from them.

Engineers' Club of Cincinnati.—At the regular meeting, November 21 the date for holding the meetings was changed to the third Thursday in each month. There being no special subject for discussion, Mr. Nicholson gave an interesting account of his experience in driving piles for trestles in the neighborhood of New Orleans, describing also the difficulties met with in the erection of buildings and their structures in and around that city on account of the marshy nature of the soil on which it is built.

Engineering Association of the Southwest.—This Society has been organized with headquarters at Nashville, Tenn. The membership is intended to include engineers in Tennessee, Kentucky, Mississippi, Alabama, and Georgia, who are not attached to other associations.

The first meeting was held in Nashville, November 21, when it was decided to hold meetings on the second Thursday of each month in that city. The following officers were elected: President, John McLeod, Louisville, Ky.; First Vice-President, W. F. Foster, Nashville, Tenn.; Second Vice-President, Edwin Thacher, Decatur, Ala.; Secretary, Olin H. Landreth, Nashville, Tenn.; Treasurer, W. L. Dudley, Nashville, Tenn. It is expected that permanent headquarters will shortly be provided for the Association.

At the regular meeting in Nashville, Tenn., December 12, Mr. Edwin Thacher read a paper on the Use of Slide Rules by engineers and architects. This paper was discussed by members present.

Arkansas Society of Engineers, Architects & Surveyors.—The annual meeting was held in Little Rock, Ark., November 12, 13, and 14, with a large attendance. The programme was well arranged by the Local Committee, who provided entertainments for the visitors. Among the papers read were the following: J. B. Gass on Fort Smith Sewerage; A. B. Matson on Municipal Improvement of Texarkana; W. E. Anderson on Highway Building; E. C. Buchanan on Miscellaneous Matters; R. D'Ailly on Forestry; H. G. Martin on Rights, Duties, and Responsibilities of Surveyors, and F. W. Gibb on Mineral Resources of Arkansas.

Western Society of Engineers.—At the regular meeting in Chicago, November 6, John E. Frohlund, Fremont Hill, and George W. Waite were elected members. Mr. A. Gottlieb was chosen representative of the Society on the Board of Managers of the Associated Engineering Societies.

Mr. Liljencrantz then read a paper on Compound Lumber, describing the works of the Compound Lumber Company at Burnham, Ill. This compound lumber consists of a core of soft wood, usually pine, faced with certain varieties of hard wood as desired, the facing being tenoned and grooved upon the core. This was discussed by members present.

Discussions on the Chicago Drainage Problem being then in order, Mr. H. A. Stoltenberg presented a paper giving his reasons against the Desplaines River plan, and stating that the best solution would be a system of intercepted waterways along both banks of the river and its branches, as suggested a number of years ago. The plan, he thought, would cost about $5,500,000, and the work could be completed in two years. Mr. R. B. Mason also presented a written discussion in favor of the system of drainage by the Desplaines River. Mr. L. E. Cooley reviewed both papers, opposing both their plans.

Engineers' Club of St. Louis.—At the regular meeting, November 20, amendments to the by-laws were adopted. A Committee to nominate officers for the ensuing year was appointed.

Mr. Robert Moore then read a paper on Railroad Culverts, describing the various forms of culvert used, with advantages and disadvantages of each, and presenting a diagram for determining the size of culvert required. The paper was discussed by a number of members present. In the discussion it was stated that iron pipes as large as 6 ft. in diameter were made for this purpose.

A regular meeting was held in St. Louis, December 4. R. S. Comlon was elected a member.

Mr. Robert Moore submitted a report from the Standing Committee on Collection of Local Engineering Data. The information furnished the Committee was of great and permanent value. Those contributing were T. B. McMath, C. V. Mersereau, S. F. Burnet, T. J. Caldwell, R. E. McMath, F. E. Nipher, J. A. Seddon, E. D. Meier, and M. L. Holman. Some data on Fuels was in preparation by Professor Potter, but had not been completed in time for this report. It was ordered that the Committee be continued and requested to present a final report as soon as convenient.

The Special Committee on Nominations of Officers for the coming year reported as follows: For President, F. E. Nipher; Vice-President, George Burnet; Secretary, W. H. Bryan; Treasurer, Charles W. Melcher; Directors, E. D. Meier and S. B. Russell; Librarian and Manager, J. B. Johnson; Manager, J. A. Seddon.

The report was accepted and the following additional nominations were made: For Vice-President, S. B. Russell; for Director, F. H. Pond.

Annual reports were received from the Secretary, Librarian, and Treasurer, and an invitation was extended to Professor T. C. Mendenhall, Superintendent of the Coast Survey, to address the Club, and to attend a banquet given in his honor.

Mr. N. W. Perkins, Jr., read a paper on Adding Machines, which treated particularly of one invented by W. R. Burrows, of St. Louis, one of which was shown. The subject was discussed by members present.

Tacoma Society of Civil Engineers & Architects.—This Society has been organized at Tacoma, Washington, and starts out with 42 members. The officers are: President, H. S. Huson; Vice-President, Arthur L. Smith; Treasurer and Librarian, Charles F. White; Secretary, William S. Gosslyn.

American Boiler-Makers' Association.—This Association, which was organized last spring, held its first annual Convention in Pittsburgh, beginning November 16. The meeting lasted two days, and about 100 members were present, representing boiler-manufacturing interests in all parts of the country. The President, Mr. James Lappan, of Pittsburgh, occupied the chair. Reports were submitted by the officers showing that the Association had started off prosperously and was well prepared for work.

The nature of the business transacted will be understood from the list of reports submitted by the special committees. These reports were on Material for Boilers; on Bracing, Stays, and Proper Tube Spacing; on Attachment of Valves and Valve-fittings; on Manheads and Manholes; on Proper Rules for Riveting and Calking; on Comparative Value of Mechanical and Hand Riveting. The Committee on Material recommended careful tests of boiler plate, especially of steel plate, and also reported against the use of cast-iron for mud-drums, legs, necks, etc., etc.—that is, any part of the boiler where it is subject to tensile strains. The use of steel castings was recommended for manhole rings and similar purposes.

It was decided to hold the next meeting in New York in July, 1890. At that meeting reports will be submitted on Safety Valves and Horse-Power; on State Inspection Laws; and on Statistics. The Association starts out well, and is expected to be of much practical service.

New York Naval Reserve.—The First Battalion of the Naval Reserve of the State of New York has been fully organized at two preliminary meetings, at which a considerable number of persons interested were present. The battalion under the law will form part of the State Militia. It will be commanded by Philip B. Low, who will have the naval rank of Lieutenant Commander, and will be composed of four companies, which will be commanded respectively by George E. Kent, F. R. Colvin, L. M. Mowbry, and W. P. Williams. All the officers are graduates of the Naval Academy at Annapolis and have seen service in the Navy. Active work will be begun at once in the instruction of the men, and, as opportunity permits, this will be extended to torpedo management, gunnery, and the handling of vessels. It is expected that the Navy Department will, as soon as possible, furnish the battalion with a training ship for part of the year.

New York Railroad Club.—The annual meeting was held in New York, November 21, and arrangements were made for the meetings during the winter season. It was stated that a number of prominent railroad men had agreed to give the Club their support, and that the prospect for a series of interesting meetings was very good. The following officers were elected for the ensuing year: President, Ross Kells; Vice-Presidents, R. C. Blackall and W. L. Hoffecker; Secretary, L. R. Pomeroy; Treasurer, C. A. Smith; Executive Committee, H. Tandy, W. C. Ennis, Thomas Aldcorn, W. H. Lewis, J. W. Baker, Thomas Millen, H. S. Hayward, and H. A. Webster.

Northwest Railroad Club.—At the regular meeting in Minneapolis, December 7, the subject for discussion was the Purification of Feed-Water. It was opened by Mr. J. L. Pattee, who read a paper giving many analyses of water. Shorter papers were read by Messrs. W. T. Reed, C. N. Hunt, and McIntosh. Mr. Hunt presented the merits of the Fields feed-water purifier, and the subject was further discussed by members present.

Western Railway Club.—A regular meeting of this Club was held in Chicago, December 17. The first subject discussed was Joint Inspection, opened by Mr. P. H. Peck.

The second subject was Testing Laboratories. Both subjects were discussed by members present.

New England Railroad Club.—At the regular meeting in Boston, December 11, Mr. R. H. Soule read a paper on Signals and Signaling. Mr. Soule gave a brief sketch of the progress of signaling in this country, and then spoke of the use of the semaphore and its different varieties. He described the different methods of making connections, and spoke on the interlocking system and the rules governing it, and of the importance of that system. He described the Saxby & Farmer system and others which have been used, and he referred to some of the large signal systems now in use in this country, including the interlocking apparatus at the Grand Central Station in New York; the New Jersey Central Yard in Jersey City, and others. He also spoke of the different connections used, by electricity, by wires, and the electro-pneumatic apparatus, a number of which are in use in Pittsburgh, Kansas City, and elsewhere. After describing the block signaling system he referred at some length to the economy secured by recent practice and by concentration of apparatus.

The subject was further discussed by members present.

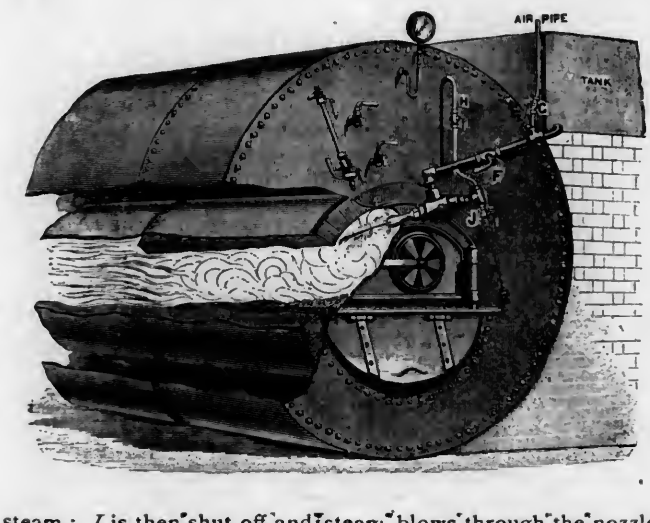
NOTES AND NEWS.

A New Mountain Railroad.—Among the many adventurous undertakings of modern times, the proposed railroad to the summit of the Jungfrau, in Switzerland, is the most remarkable. The engineers who have prepared the plans, however, have before them the success which has attended the opening of similar lines, for instance, the Rigi Railroad, the Montreux Railroad, the Pilatus Railroad, and last, not least, the Vesuvius Railroad, besides other lines of minor importance. But all those mentioned may be considered child's play compared with the line now proposed. The Jungfrau has an elevation of over 13,000 ft., and its upper slopes are eternally covered with ice and snow, excepting those parts too steep for snow or ice to hold on to. A Swiss engineer, Herr Köchlin, of Zürich, however, has demonstrated the practicability of the railroad, and sent to the Swiss Federal Council an application for a concession. The line proposed starts from the Lauterbrunnen station of the Interlaken & Lauterbrunnen Railroad, now building, and is to be altogether about six miles long. It is divided into two sections, the valley line, which is comparatively easy of construction, and the mountain railroad proper. The latter is to be either a rack-rail line or a wire-rope railway in five stages, placed one above the other. The rise of the rack railway would be 1 in 2, and for working such a steep gradient it is proposed to use electricity, the current being conveyed along the rack-rail. Should wire-rope traction be adopted, hydraulic power would be used, in a very simple manner, a carriage weighted with water descending, and hauling up, by a wire-rope, another carriage on an adjacent line. This is the system employed at the Montreux Railroad, where the rise in some portions is as much as 1 in 1⅗. The length of the mountain line would be 3½ miles. To protect the railroad in the more exposed portions, it would run there in tunnel, the longest tunnel being near the summit. To provide for the accommodation of travellers, a hut of refuge and an hotel, as well as an observatory, are to be established on the summit. It is anticipated that fully 30,000 visitors yearly would avail themselves of the facility offered for ascending the Jungfrau, a mountain full of difficulties, but presenting no danger to experienced mountaineers accompanied by good guides. The cost of construction is placed at $1,950,000, while the annual revenue, supposing the number of travelers were to reach the total estimated, would be $202,500, the fare proposed being 35 francs ($6.75) for the round trip.

Tall Chimneys.—There has just been completed, at the Fall River Iron Works, Fall River, Mass., the tallest smoke-shaft in the United States, described by its owners as "the tallest chimney in the world designed solely for making a draft for boilers." To this statement we must take exception. The chimney in question is 340 ft. high above its granite base, and 30 ft. square at the bottom. It is 5 ft. higher than one at East Newark, N. J., which reaches an altitude of 335 ft., including its bell. There is also one at Boston, Mass., 200 ft. in height, and another at Providence, R. I., 180 ft. high. The "tallest chimney in the world" is that at Townsend's, Port Dundas, Glasgow; in fact, three higher stacks exist in this country than that at Fall River. They were, however, constructed for carrying off noxious fumes from chemical works, and not for creating a draft for steam-boiler furnaces. These three chimneys are that mentioned at Port Dundas, which is 454 ft. high; Saint Rollox, Glasgow, 436½ ft. in height; and Dobson & Barlow's, Bolton, 367 ft. high. There has also been completed, at Freiberg, Saxony, a very high chimney, intended to carry off blast-furnace gases at the Freiberger Muldenhütten. This chimney has a base 39 ft. 4 in. square, and rises to a height of 443 ft., where it ends in a circular opening 10 ft. in diameter. The Fall River chimney will furnish draft for the boilers of four new factories. It should be added that it requires the highest skilled labor to construct high chimneys, and the slight-

est deviation from fixed rules as to the reduction of diameter, or the failure to construct the cores, extending from the base to the top, would result in the collapse of the whole structure.—*Iron.*

A New Liquid Fuel Burner.—The liquid fuel injector illustrated herewith has been specially designed by its inventor, Mr. Stewart, for firing boilers with liquid fuel instead of coal, or as an auxiliary to coal, and is adopted by proprietors of oil works and others. By using the injector complete combustion, without smoke or smell, is secured, and waste products, as shale, tar, oil, etc., are utilized. The apparatus when started is self-acting, and will burn and keep up steam as long as the fuel supply is continued. Being automatic, one boiler attendant can overlook a large number of boilers. There is nothing complicated to get out of order, and, when fixed and regulated, will work continuously and without any special attention. The injector is also used as an auxiliary where there is not enough boiler power. By using it in this way much better results have been obtained than by using coal alone. The injector is made of gun-metal, the nozzle being of brass, or other metal suitable for resisting the action of acids. The steam-pipe is connected to the nipple at the end of the injector; the brass nozzle is inserted in the front wall of the furnace in a hole above the furnace door, at a slight angle, as shown in our engraving, the orifice being horizontal. The tar or oil feed-pipe is connected to the injector by being screwed into the projecting pap in the body, a branch pipe is attached to the feed-pipe by a T-piece, which allows a cock *G* to communicate with the atmosphere, and so allows air to pass in with the liquid fuel. The steam, tar or oil, and air are controlled by cocks or valves on the several pipes. *H* represents the steam-cock on the steam-pipe, and one method of connecting it to the boiler. *F* is the fuel supply-pipe and cock; *G* the air cock; *J* a pet cock attached for discharging condensed water when the injector has been shut and standing. The ordinary furnace bars are covered over with dross, and the air supply is regulated by a ventilator-valve in the furnace door and the air pipe *G*. The action of the injector may be described as follows: Cocks *H* and *J* being opened, steam blows through and clears the pipes of condensed



steam; *J* is then shut off and steam blows through the nozzle. The fuel and air cocks *F* and *G* are now opened and regulated, and a mixture of steam, oil or tar, and air passes through into the furnace or combustion chamber in a highly inflammable state; and, being ignited by the fire in the furnace, burns with an intense heat, which can be so regulated by the fuel and air supply as to consume all the products of combustion, and thoroughly prevent smoke. If such a strong heat is not required, it can be regulated and moderated to any extent required by the controlling cocks and valves for regulating the supply. The apparatus is made by Messrs. P. & W. MacLellan, 129 Trongate, Glasgow, Scotland.—*Iron.*

Submarine Torpedo-Boats.—The Spanish submarine torpedo-boat *El Peral*, has recently completed a series of under-water trials at San Fernando Arsenal, near Cadiz. The preliminary trials of this little vessel took place in March last, but were rendered nugatory through a serious mishap to the machinery. The recent trials, however, have been so far satisfactory that further experiments are to be carried out before a Naval Commission. If the experiments prove successful, a number of these vessels will be constructed for the coast defense of Spain. The boat was designed by Lieutenant Peral of the Spanish Navy, and is a cigar-shaped vessel of 87 tons' burden, propelled and manœuvered by four screws driven by powerful electrical machinery. The current is supplied by accumulators calculated to admit of a continuous run of 326 miles.

The French naval authorities have also been investigating the properties of submarine vessels, and a boat of this type, invented and designed by M. Goubet, has recently been introduced into the French Navy. It is of extremely light construction, and attached to the bow is a pair of curved shears several feet in length, to be used in cutting away the net defenses in an attack upon an iron-clad. The torpedo is attached to the hull of the boat on the outside, and can be disengaged at the will of her commander. The motive power in this craft is also electricity.—*Nautical Magazine.*

A Military Exhibition.—It is proposed in England to hold next year a Military Exhibition on a pretty extensive scale in the grounds of the Royal Hospital, Chelsea. The scope is a wide one, comprising the following sections: 1. Mechanical and military inventions. 2. Models and plans. 3. Freehand drawing, sketching, penmanship, and illumination. 4. Oil and water-color drawings. 5. Photography and lithography. 6. Uniforms and accoutrements. 7. Commissariat, transport, and camp equipment. 8. Ambulance. 9. Arms and ammunition. 10. Metal work. 11. Wood-carving, turning, fretwork, and joinery. 12. Saddlery and leather work. 13. Tapestry and needlework. 14. Decorative design in leather and paper. 15. Military music. 16. Musical instruments. Manufacturers' exhibits will be received in Sections 1, 5, 6, 7, 8, 9, 12, and 16. Competitions will be held in machines for the supply of hot tea, coffee, etc., for filters, camp equipments, canteens, and scientific instruments for field service. The Exhibition will be opened about May 1, and last for five or six months. The Honorary Secretary is Major G. E. W. Malet, 140 Palace Chambers, Westminster, S.W., London.—*Industries.*

The Life-Saving Service.—The annual report of the General Superintendent of the Life-Saving Service shows the following:

At the close of the fiscal year the establishment embraced 225 stations, 172 being on the Atlantic, 45 on the lakes, 7 on the Pacific, and 1 at the Falls of the Ohio, Louisville, Ky. Since then three new stations have been established, and seven new stations are now under contract—viz.: Wallis Sands, N. H.; Knobbs Beach, Cuttyhunk, and Point Allerton, Mass.; Fort Point and Point Reyes, Cal., and Point Adams, Ore.

The work of the service during the year is summarized as follows: Number of disasters, 528; value of property involved, $6,416,775; value of property saved, $5,054,440; value of property lost, $1,362 335; number of persons involved, 3,426; number of persons lost, 42; number of persons succored, 787; days of succor afforded, 1,726; number of vessels totally lost, 63; number of vessels otherwise aided by crews, 510; number of vessels warned from danger by signals of patrolmen, 217; number of persons rescued who had fallen from wharves, piers, etc, 24.

The assistance to vessels and cargoes, the report says, is still increasing, being greater this year than ever before; but the cost of maintaining the service is somewhat less than last year, being $293,397.

The General Superintendent renews his recommendation of last year for an increase in the pay of the surfmen.

A Remarkable Water Power.—One of the most remarkable instances of electrical transmission of power has only recently been accomplished in the State of Nevada, on the world-famous Comstock Lode and the almost equally famous Sutro Tunnel. At the Nevada Mill there is a 10-ft. Pelton water-wheel, which receives water through a pipe-line delivering water from the side of Mount Davidson under a head of 460 ft., giving 200 H.P. Here the water is again caught up, delivered into two heavy iron pipes and conducted down the vertical shaft and incline of the Chollar Mine to the Sutro Tunnel level, where it is again delivered to six Pelton water-wheels, this time running under a head of 1,680 ft. Each of the six wheels is but 40 in. in diameter, weighing 225 lbs.; but with a jet of water less than ⅝ in. in diameter they develop 125 H.P. each. On the same shafts, which revolve 900 times a minute, are coupled six Brush dynamos, which generate the current for the electric motors that drive the stamps in the mill above ground. The result is, that, where it formerly took 312 miners' inches of water to operate 35 stamps, but 72 in. are now required to run 60 stamps. This is the most enormous head of water ever used by any wheel, and by itself constitutes an era in hydraulic engineering. A solid bar of iron thrown forcibly against this tremendous jet rebounds as though it had struck against a solid body instead of a mobile fluid. The speed of this jet, where it

impinges against the buckets of the wheel, is *two miles* a minute —176 ft. a second. . . . .

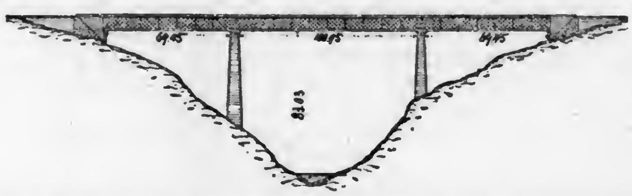
There is another quality of these extraordinary wheels which renders them absolutely without a peer in the large family of prime-movers. This is the immense power exerted per pound of weight. Those in the Chollar Mine, for instance, give out 1 H.P. for every 1.8 lbs. of weight. If there is anywhere a motor which begins to compare with them in this respect, I have never been favored with knowledge of it. And it seems there is no limit, outside of that which sets bounds to the head of water itself, to prevent further progress of the wheel in the same direction.—*Alvan D. Brock, in the Overland Monthly.*

The Tardes Viaduct.—This Viaduct, which was recently completed, and which is described in the publication of the French Ministry of Public Works for 1889, carries the railroad from Mont Lucon to Eyguraude across the valley of the little river Tardes. It consists of two continuous riveted lattice girders resting upon two abutments and two piers, forming a bridge with three openings, the central one being 331.13 ft., and the two side openings, 227.80 ft. span.

The girders forming the bridge are 27.22 ft. in depth, and are spaced 18.04 ft. apart between centers. It is a deck bridge, the track being carried upon the upper chords of the trusses, and in addition to the tracks there is on each side a foot-walk 2.62 ft. in width. The two girders are connected by horizontal and vertical cross-bracing and wind-bracing. The tracks are carried on longitudinal wooden sleepers, which are supported by cross-girders resting upon the upper chord and spaced 8.38 ft. apart.

The height from the surface of the water in the river to the lower chord of the truss is 272.34 ft., and from the river to the level of the track, 299 57 ft. The piers are, respectively, 157.44 ft. and 196.64 ft. in height, and are 26.24 × 14.76 ft. in size at the top. The piers and abutments are built of granite, and the foundations rest upon the bed-rock of the valley, which is very near the surface.

The structure is proportioned to sustain the heaviest lateral pressure possible from the wind, the calculations being based upon observations taken in the neighborhood. The accom-



panying illustration shows a general view of the bridge. Its total cost was $268,800, including foundations, masonry and superstructure. The bridge was built by M. Eiffel, as contractor, from the designs of the Chief Engineer, M. Daigrembut.

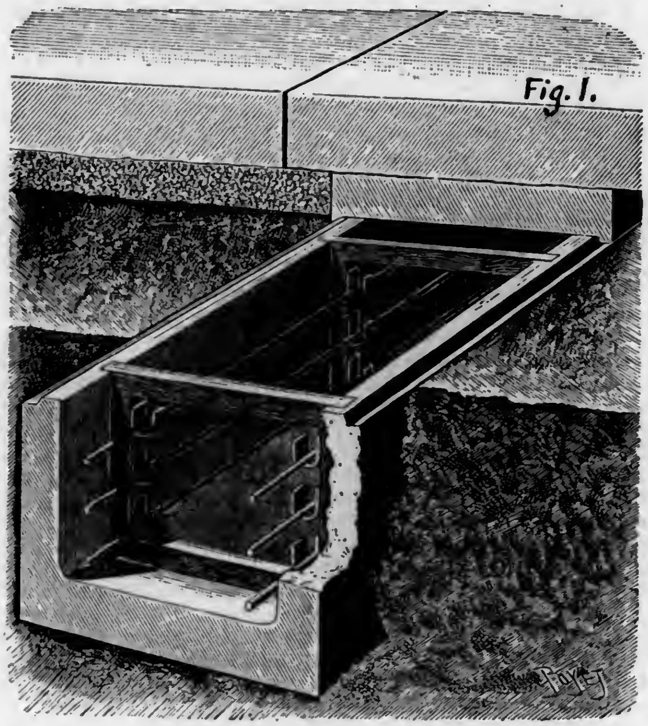
Underground Wires in Paris.—*Le Genie Civil*, in describing the electric light plant at the Halles in Paris, gives an account of the methods used in laying the wires under ground, from which we condense the description below.

The question of laying the cables of the exterior circuit was of considerable interest. The Municipal Council authorized the use of the sewers, but in spite of this the engineers have preferred to build special conduits, and the type adopted seems to solve the problem very well.

Already encumbered as they are, the sewers are not well adapted to new installations of this class. The dampness of them is not favorable to the preservation of the current, and disturbing inductions might result between the electric light cables and the telephone wires. Moreover, accidents to the cable are always to be feared from the negligence, or perhaps even the malice, of the men employed in the sewers; and finally the perfect insulation required would have been exceedingly extensive. The cables, therefore, have been placed under the sidewalks in conduits of the form shown in fig. 1, made of cement and 0.26 × 0.30 m. (10.23 × 11.80 in.) in size. Wooden supports furnished with glass holders, which carry the cables, are placed at distances of 1.50 m. (4.92 ft.) apart. These wooden supports slide freely in grooves made in the conduit, and thus form a method of suspension easily accessible for repairs. In crossing the streets, where the soil is very damp and permeable, cables are sunk one meter below the surface, and the connection with the conduits under the sidewalks is made as shown in fig. 2. At each angle an opening or manhole is provided, as shown in the cut.

For the circuit at low tension the cables are made as follows: the conductors are wires of tinned copper, of number and diameter variable according to circumstances. These wires are twisted together and covered with a layer of pure rubber; then with a layer of mixed rubber at least 2 mm. (0.08 in.), and finally by two bands of cotton impregnated with rubber. The whole cable is vulcanized in a compact mass, and is then protected by an outer covering of hemp soaked in rosin or tar.

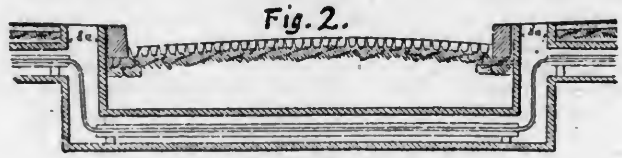
For the high-tension circuit, on account of the narrowness



of the sidewalk in certain streets, it was necessary to use, for a short distance, the sewers, and in order to avoid any disturbance of the telegraph and telephone wires on these sections, use was made of concentric cables. These cables were thus formed: A core of 19 copper wires of 2 mm. (0.08 in.), giving a section of 60 sq. mm. (9 3 sq. in.); the wires outside were covered by two layers of pure rubber 1 mm. (0 04 in.) in thickness, and then by several layers of vulcanized fiber wound in different directions; outside of this was a series of copper wires rolled in helical form and forming the second circuit, having the same total section as the core. These were covered in turn: First by two layers of pure rubber; then by several layers of vulcanized rubber 3 mm. (0 12 in.) thick; then by two vulcanized bands wound in opposite directions; then by hemp 3 mm. (0.12 in.) in thickness and saturated by a resinous composition, and then by two bands of vulcanized cotton. The whole was enclosed in a leaden pipe 2 5 mm. (0.10 in.) in thickness, which again was covered by twisted cord. This cable rests on wooden supports fastened in the masonry of the sewer.

For the ordinary high-tension cables the conduits are similar to those for the low-tension cables described above. The degree of insulation was carefully provided for in the specifications. These cables rest on wooden supports injected with sulphate of copper and covered with tar, which rest on porcelain insulators in the cement conduits, as shown in fig. 3. At the crossings of the streets the conduits are arranged as shown above in fig. 2.

Fig. 2.



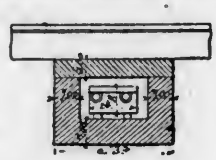


Fig. 3.

The total length of 900 m. (2,952 ft.) of concentric cables in the sewers and 5,800 m. (19,024 ft.) of the ordinary cables was put down at a cost of about $14,800.

The current furnished from the light station is sent out under a pressure of 24 volts. As it is furnished to each user under a tension of 100 volts, it is necessary to use transformers between the main circuit and each side connection.

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NEW YORK, FEBRUARY, 1890.

THE New York Railroad Commission in its annual report makes a number of recommendations to the Legislature as usual, some of them being a repetition of those made in former years, to which—as the Commission not unnaturally complains—the Legislature has not paid the slightest attention. The most important of these recommendations is that suggesting an amendment of the law providing for a review of the Commissioners' recommendations by the courts and their enforcement by action of the courts, should they be found just and reasonable. Akin to this is the recommendation that a penalty be provided for failure on the part of the companies to file the quarterly reports now required by law. Another important recommendation is that all future grade crossings of railroads and highways be prohibited by law, and that provision be made for the separation of grades between railroads and highways at crossings now existing.

One equally important is that the consent of the Railroad Commissioners be required before a new railroad company can be organized. This is intended to prevent unnecessary duplication of railroads and the construction of parallel roads which are not required.

The other recommendations are for acts to prevent discrimination ; to establish responsibility in the case of damage by fire ; to regulate the leasing of roads ; to require the use of a center-bearing rail for street railroads ; for the use of the railing on the tops of freight cars, to protect brakemen, and for the use of a thermometer in passenger cars.

THERE has been some revival recently of the project—which was originated, we believe, by Mr. H. R. Helper some years ago—for a railroad to connect North and South America, running through Mexico, Central America, and South America. It is possible that this project may be realized some day, but if so, it will be done by the gradual extension of the railroad systems of the different countries and their connection, and not by the construction of a single line.

Considerable progress in this direction has already been made in the building of railroads in Mexico, and much more will probably be done in that country and Central America during the next 10 years. In South America the building of the Pacific Railroad connecting the Argentine Republic with Chili, and crossing the continent from Buenos Ayres to Valparaiso, will probably be followed by an extension to and into Bolivia, now the most remote and inaccessible of South American countries, while a railroad through the valley of the Upper Amazon, connecting Bolivia and Brazil, and possibly Peru, also is among the probabilities of the near future. All of these roads will supply links in the proposed line, but the time when North and South America will have complete connection by railroad is still remote.

THE Marine Conference at Washington proved to be a more steady and hard-working body than such conferences generally are, and has really accomplished a great deal of useful work. A complete code of sound signals for use at night or in bad weather was adopted, and also a code of rules designed to prevent collisions. This includes distress signals for vessels requiring assistance, and also signals to indicate the course to be taken in clear weather when vessels can be seen.

General codes of rules for designating and marking vessels and also for saving life and property from shipwreck were adopted, and also uniform rules for reporting and marking wrecks and other obstructions to navigation, for buoys and beacons, and for notices of new dangers discovered.

The Conference decided that no international regulations to determine the seaworthiness of vessels could be made which would secure beneficial results, and also decided that it was not expedient for the present to establish any permanent International Commission. It was decided, however, to invite all maritime countries to take into consideration the use of a uniform system of storm-warnings, and that such a system should, as far as possible, indicate whether the storm is approaching or has passed the stations where they are displayed.

While the recommendations of the Commission are not binding upon the nations which they represent, they have been so carefully made and with such authority, that there is very little doubt that they will be adopted substantially by all the leading maritime powers.

TRAINS have at last begun to run over the great bridge across the Kills, between Staten Island and the New Jersey shore. The bridge has been finished for over a year past, but has not been in use, because the railroad connection on the New Jersey side was not completed. This has now been finished and trains are running to the Staten Island terminus.

The bridge itself has a draw-span 500 ft. long, with two fixed spans of 150 ft. each, being thus comparatively short. On the Staten Island side there are 6,000 ft. of trestle, and on the New Jersey side 4,000 ft. of trestle in the approaches. It is owned by the Baltimore & Ohio Railroad Company.

WORK has been resumed on the tunnel under the Hudson River between New York and Jersey City, as has already been noted. The north tunnel, starting from the New Jersey side of the river, has been pumped out, and some progress has been made upon its extension, and a

commencement of work has been made at the New York end. Nothing has as yet been done to the south tunnel, which had been extended some distance under the river when work was stopped in 1887. The project has been taken up by English capitalists who have agreed to furnish the funds necessary for carrying on the work, and it is understood that it will shortly be taken up by an English contracting firm, Pearson & Son, who will introduce new methods of work. They will use, it is said, what is known as the Greathead shield in making the excavations under the river. There are many questions as to terminal arrangements and the extension of the tunnel from the river line under the city in New York which are yet to be settled.

THE Board appointed by the Secretary of the Navy last summer, to lay down a general plan for the future increase of the Navy, has, it is understood, prepared a very extensive programme. It includes the building of 10 battle-ships of 10,000 tons displacement ; eight of 8,000 tons ; 12 of 7,000 tons, and five of 6,000 tons each ; 10 rams of 3,500 tons displacement each ; 15 torpedo cruisers of 900 tons each, to make not less than 22 knots an hour. This will complete the fighting or coast-defense fleet. The cruising navy under this plan would include nine armored cruisers of 6,250 tons displacement and 19 knots speed ; four protected cruisers of 7,400 tons and 22 knots speed ; nine protected cruisers of 5,400 tons and 20 knots speed ; two protected cruisers of 4,000 tons and 19 knots speed ; and five special cruisers of 1,200 tons and 18 knots speed. In addition to these there would be built as tenders three artificers' or engineers' ships, provided with appliances for repairing and for aiding vessels in distress. The construction of such a fleet, it is estimated, would involve an expenditure of nearly $280,000,000. Of course, it is not intended that all these vessels should be built or even commenced at once, but in the opinion of the Board it will require the whole number to constitute a navy of modern construction, and suitable to the dignity and power of the United States. It is proposed to extend the building of these vessels over a period of 14 years, about $20,000,000 per year being thus required.

THE Hale bill, which has been introduced into the Senate, provides that the Department be authorized to begin work on eight battle-ships, two armored coast-defense vessels, three gun-boats, and five first-class torpedo boats. All of these vessels will be in accordance with the general plan outlined by the Board. There is very little doubt that liberal appropriations will be made for the Navy this year, and not much doubt also that they will follow the general line of the recommendations of the Secretary, and will be for fighting ships rather than for cruising vessels.

THE total number of passengers carried by the New York City lines, as shown by their reports to the Railroad Commission for the year ending September 30 last, was as follows for two years :

	1889.	1888.
Elevated Lines	179,497,433	171,529,789
Surface Lines	209,386,816	205,383,797
Total	388,884,249	205,383,797

The increase last year over 1888 in the total number of passengers was 11,970,663 ; a gain of a trifle over 3 per cent. only. In 1888 the increase over the previous year was about 5 per cent., and in 1887 it was 11½ per cent. There was no reason last year for any extraordinary gain, but it is a little surprising that the movement remained so nearly stationary.

The greater part of the increase fell to the share of the elevated lines, which last year carried 46.2 per cent. of the total, against 45.5 per cent. in 1888, so that the conditions of travel in the city cannot be said to have changed to any great extent during the year. There was a greater increase, however, in the number carried by the cross-town lines than in those on the lines running up and down town, but the difference was not large enough to be notable.

Practically also, there were no additions to the length either of elevated or surface lines in the city, the only change being a short extension of the Suburban Elevated line, which is not as yet a very heavy passenger carrier, although it probably will be in the future.

Under these circumstances we would not expect any great change in the equipment. That of the elevated roads remains the same in number as the previous year—291 locomotives and 921 cars. The surface roads report 2,373 cars, an increase of 240, and 14,764 horses, an increase of about 1,200 in number.

Several changes are in contemplation on the city railroads in the way of substituting cables or electric power for horses, and, as is well known, there are numerous plans for new elevated railroads ; but there have been no new developments during the year, and it is still somewhat doubtful whether there will be any during the present year.

INTERNATIONAL TRIAL OF LOCOMOTIVES DECLINED.

THE Secretary of the Edinburgh International Exhibition, to be held next summer, has written to *Engineering* saying that invitations have been addressed to the seven chief locomotive builders in the United States to send a representative American express engine for exhibition and practical trial, which have all been declined, on the ground that the expense would exceed any benefits likely to accrue. He says that the invitations provided for the American engines being worked throughout by American engineers, and stated that fair play in every respect would be guaranteed.

The Engineering Committee of the Exhibition have addressed a letter to the Baldwin Company, asking whether they would send an engine if all expenses were paid.

The Secretary says that, "when the idea was first mooted Americans in this country hailed it enthusiastically, and expressed confidence that an engine would not only be sent, but that it would be backed to beat the British ones to the tune of hundreds of thousands of dollars. It would seem that a change has since come over these views ; but still it might reasonably be imagined that a sufficient number of public-spirited Americans could be found to provide the necessary funds to recoup the Baldwin Company for the outlay. Even should freight have to be paid on the engine, the total expense could not well exceed $5,000, a mere bagatelle to set against the loss of prestige to American builders which the declining of such an invitation must involve."

It appears then that the British Lion has knocked a chip off of the horns of the American Buffalo, and that up to date the tail of the Buffalo is quiescent. Why is this thus ?

Where are Edward Bates Dorsey, Mr. Strong, and Mr. Lockwood? Messrs. Locomotive Builders, the American Eagle blushes for you.

FIRE-BOXES LINED WITH FIRE-BRICK.

THE *Railroad Gazette* is "rather surprised to find advocates of fire-boxes lined with fire-brick cropping out at this date, when the effects of the heat retained in that most valuable device, the brick-arch, are so well known to all who have tried to blow-off and quickly wash out locomotive boilers, equipped with it, after a hard run." It quotes the experience of an Eastern road on which a device which had a complete fire-box lining of considerable thickness was tried. The locomotive, it is said, made steam very slowly before starting, but "when the end of the run was reached, went on making steam as though it was never going to stop."

It is said further, that "the round-house fireman did not dare to leave the engine by itself for fear of burning the crown-sheet, and the crew were held until the fire-brick storehouse of heat had exhausted itself and cooled down to a safe temperature." From this slight and traditional evidence, it is concluded that "as a lining to cover up heating surface the presence of fire-brick is detrimental, and that theory which leads one to suppose that a locomotive fire-box would be better if lined throughout with a coating of brick is a delusive one, and one that has been tried and found wanting in practical value."

Who it is that proposes to use fire-brick as a lining to cover up heating surfaces does not appear. Certainly those who are successfully using fire-brick lined fire-boxes do not propose to "cover up heating surfaces" with it. Mr. Verderber did not, Mr. Urquhart, Mr. Liddell, the Erie Iron Works, nor the engineers who adopted it on various ships do not. If heating surfaces are not covered with fire-brick, it is difficult to see how, on heavy grades, "the well-known low heat conductivity of fire-brick would act to prevent the access of heat of the fire-brick to the furnace walls, and would thus have been an actual barrier to evaporation, and would have reduced the capacity of the boiler to furnish steam under a hard pull enormously." This "difficulty" is an imaginary one.

To the charge that such fire-boxes will generate steam after the fire is withdrawn, it may be said that some thousands of stationary boilers, with brick furnaces, are open to the same objection, and yet, quite curiously, we never hear of any trouble growing out of it. But let us see how much heat a fire-brick fire-box will hold. If the fire-brick is 5 in. thick, the lining of an ordinary box 6 ft. 6 in. long would weigh about 6,700 lbs.

It will also be supposed that at the end of the run this is heated to a temperature of 1,000°, and that the steam pressure is 150 lbs. Now the temperature of the water under a steam pressure of 150 lbs. is 366°. When the fire-brick is cooled down to that temperature, no more heat will be transmitted to the water. Consequently, it is only the difference between these temperatures, or 634° of heat, which can be transmitted to the water. The specific heat of brick is only one-fifth that of water, so that the amount of heat in the fire-brick which can be utilized in making steam would be ascertained by the following calculation, $\frac{6,700}{5} \times 634 = 849,560$, or, say, 850,000 units of heat. It takes 858.9 units of heat to convert a pound of water into steam of 150 lbs. pressure if the water is heated to the temperature of the steam. Therefore the heat in the fire-box would convert a little less than 1,000 lbs. of water into steam if all the available heat was transmitted to the water. This would be equivalent in effect to the combustion of about 140 lbs. of coal, on the improbable assumption that all the heat above 366° is transmitted to the water in the boiler. If this should actually occur, the obvious way out of the difficulty would be to burn 140 lbs. less of coal before the end of the run. In other words, if a fireman had not wit enough to adjust his fire to the new condition of things which would exist if fire-boxes lined with fire-brick were used, then the difficulties imputed by the writer in the *Railroad Gazette* would occur, but they might and sometimes do occur when anthracite coal is used for fuel, and might with other fuel.

It is true that fire-brick will take a longer time to cool than a boiler will without it, but considering the great advantages which would result if we could dispense with all fire-box plates, excepting the tube-sheet, all stay-bolts, crown-bars, and flanged sheets, which are the most expensive parts of a locomotive to construct and maintain, and considering the damage which is sometimes done by cooling boilers off too suddenly—none of which advantages does the writer in the *Gazette* seem to recognize—some stronger objection must be brought to the use of fire-brick than that of inconvenience in washing out the boiler to prevent such fire-boxes from being adopted. All that is advocated is that the apparent merits of this kind of fire-boxes make it worthy of a thorough trial. None of those who are now using them make the objections our contemporary does; perhaps it is because they have not given heed, as he has, to some story which is apparently little more than a tradition.

COUNTERBALANCING THE REVOLVING AND RECIPROCATING PARTS OF LOCOMOTIVES.

THIS is an old subject and has been under discussion for 40 or 50 years, but notwithstanding the fact that it has been talked and written about so much, it is still very imperfectly understood by many persons who are in positions where such knowledge would be useful to them and valuable to their employers.

As a prelude to an explanation of the principles of counterbalancing locomotives, it may be remarked that it is impossible to do it perfectly with the ordinary means that are employed for that purpose. The disturbance caused by the action of the reciprocating parts may be lessened up to a certain point, but there it becomes merely a choice between two evils—if one of them is diminished the other is increased, and *vice versa*—as will be explained further on.

If a revolving shaft or wheel of any ordinary machine has more weight on one side of its center than on the other—or is "out of balance," as it is called—the machine, unless it is very securely fastened, will shake when the shaft or wheel revolves rapidly; or, if the revolving part is free to move laterally, it will "wobble." This action is shown if we fasten a weight to one side of an ordinary spinning top; or, better still, by a model of a pair of locomotive wheels on an axle suspended from journal-bearings by elastic india-rubber bands, so that the wheels and axle can turn freely and swing horizontally. The elastic

bands will also allow the wheels and axle to vibrate vertically. If a twine is wound around the axle of a model thus suspended, and a weight is attached to the twine, the descent of the weight will cause the axle and wheels to revolve. If they are balanced they will have very little horizontal or vertical movement; but if a weight is attached to one of the wheels, at some distance from its center, and they are then made to revolve, they will vibrate more or less violently both vertically and horizontally in proportion to their speed, owing to the effect of the centrifugal force of the weight. This force is exerted away from the center of the axle in the direction of a radius drawn through the center of gravity of the weight and the center of the axle. As the wheel and the weight attached thereto are revolving, the direction in which this centrifugal force is exerted is continually changing, and pulls the wheel first in one direction and then in another, which causes it to vibrate sideways and up and down.

If an equal weight is attached to the opposite side of the wheel, and at the same distance from its center as the first one, then the centrifugal forces of the two weights will act in opposite directions and the two will balance each other, and there will be no disturbance in the revolution of the wheels, and if the weights balance each other accurately the wheels will have little or no lateral or vertical movement, showing that the centrifugal force of the one weight neutralizes that of the other. It is not essential, though, that the two weights should be equal to each other and at the same distance from the center of the wheel. All that is needed is that the products of the weights multiplied by their distance from the center of the wheel should be equal. Thus, if one weight is equal to 150 lbs. and its center of gravity is 12 in. from the center of the wheel, then it may be balanced by another weight of 90 lbs. 20 in. from the center of the axle on the opposite side, because $150 \times 12 = 1800$ and $90 \times 20 = 1800$.

The action of an unbalanced revolving weight is shown in fig. 6, in which A is a shaft, $c\,A$ a crank, and c a crank-pin, and C a weight attached to the crank-pin. When the crank is turning the tendency of the weight is to move in a straight line $c\,f$, tangent to the circle in which it is moving, and away from the center of the shaft. As the crank-pin moves in the dotted circle it constantly pulls the weight from a tangent path into the circular one in which the crank-pin is revolving. There is therefore a constant pull on the crank-pin away from the center of the shaft in every position of its revolution. This is equal to the centrifugal force of the revolving weight.

The amount of this pull may be ascertained by the well-known rule for calculating centrifugal force, which is as follows:

Multiply the weight of the revolving body in pounds, the square of the number of revolutions per minute, the radius or distance in feet from the center of motion, and .00034 *together, and the product will be the centrifugal force.*

The effect of an unbalanced weight at the crank-pin of a locomotive driving-wheel is illustrated by figs. 1–5, in which the large circles represent the circumference of a driving-wheel in four different positions. A is the axle and C the crank-pin and W a weight attached to the crank-pin. When the wheel is revolving, and is in the position shown by fig. 1, the weight W will exert a centrifugal force against the pin in a direction away from the axle, as indicated by the dart d. The effect of this is that a pressure is communicated to the axle which pushes against the driving-box and frame, and the force thus has a tendency to move that side of the engine ahead, if it is running in the direction indicated by the dart K.

When the crank-pin is in the position shown in fig. 3 the centrifugal force of the weight again acts away from the center of the wheel and pushes the crank-pin and wheel backward. In the position shown by fig. 2 it pushes downward and in fig. 4 upward, as indicated in each case by the darts d. When the crank-pin is in the position shown by the dotted circle c, fig. 1, the centrifugal force is exerted in a diagonal direction, as indicated by the dotted dart $c\,A$.

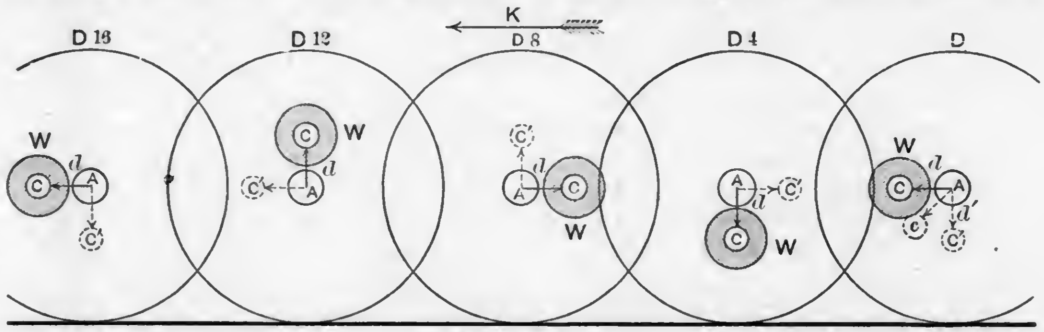


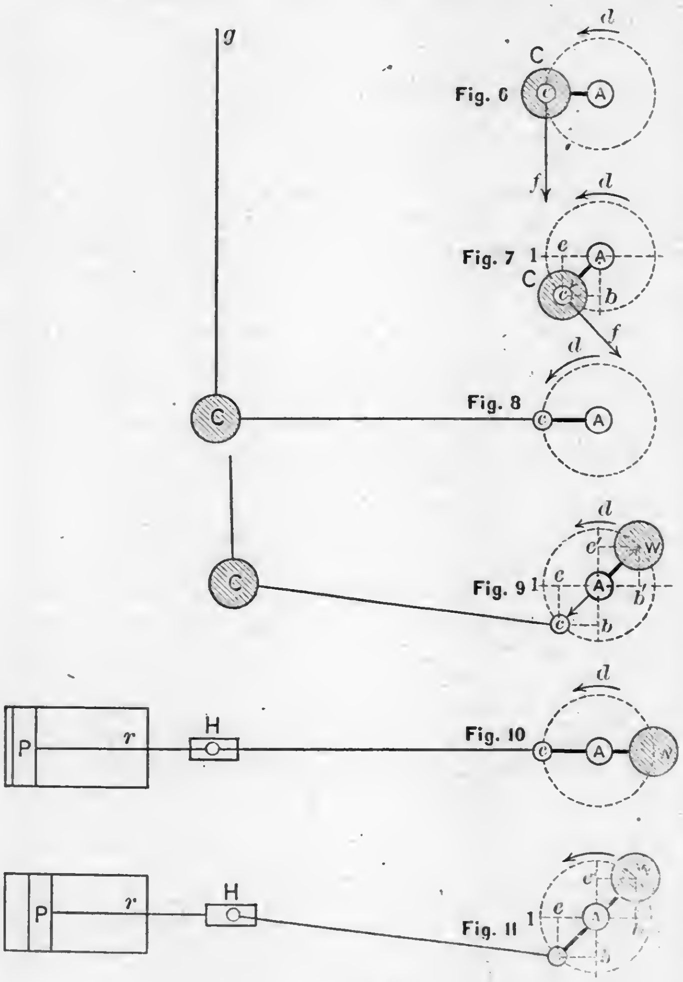
Fig. 5 Fig. 4 Fig. 3 Fig. 2 Fig. 1

When the crank-pin C, on the nearest side of the engine, is in the position represented in fig. 1, the crank-pin on the opposite side is in the position represented by the dotted circle C'. The centrifugal force of the revolving weight on this crank-pin is then exerted downward, or in the direction of the dart d'. In fig. 2 the centrifugal force on C' pushes backward, in fig. 3 upward, and in fig. 4 forward. When the centrifugal force is exerted either forward or backward on one side of a locomotive, the tendency is to produce what is called "nosing," or a horizontal movement of its front or back ends around a vertical axis between them, or a longitudinal jerking motion. When either of the crank-pins is above the axle, as in figs. 3 and 4, the upward pressure on one side has a tendency to lift that side of the engine; or, if either is below the axle, as in figs. 1 and 2, the centrifugal force is exerted downward and presses on the rail below the wheel.

As explained above, a revolving weight may be balanced in so as to cause very little disturbance, by simply putting a counterweight in each wheel opposite the crank-pin, whose weight, multiplied by the distance of its center of gravity from the center of the axle, will be equal to the weight at the crank-pin multiplied by the distance of its center from that of the axle, or half the stroke. In a locomotive the revolving weights of each wheel consist of the crank-pin boss, crank-pin, one-half the coupling-rod or rods connected to the wheel. For each of the main driving-wheels, there must be added to these weights that

of the back end of the main connecting-rod. When the main rods are connected to the inside journals of the crank-pins—that is; to the journals nearest to the wheels —a weight in the wheels equivalent to that at the crank-pins gives a sufficiently perfect balance of the revolving parts for all practical purposes, but when the main rods are connected to the outside journals, the counterweights should be modified somewhat, as will be explained further on.

It remains to explain how the reciprocating parts may be balanced. Supposing that *c A*, fig. 6, is a crank on the shaft or axle *A*, and revolving around it, and that *C* is a weight attached to the crank-pin *c*. If the crank is revolving in the direction indicated by the dart *d*, then the



weight, if unconstrained, would move in a direction at right angles to *A c*, as indicated by the dart *c f*. Instead of being free to move in that direction, the crank, as has been explained, pulls the weight toward the center of the wheel and causes it to revolve in a circular path around the axle. As the weight resists this constraint, considerable pull must be exerted by the crank to draw the weight *C* from the path *c f*, which it would take if it was detached from the crank when it reached *c*.

This pull is the centrifugal force of the revolving weight. When it reaches the position shown in fig. 7, if it was free to move, it would take the direction *c f* at right angles to the crank *c A*, but the crank continues to pull it toward the center of the shaft *A* in the direction *c A*, and compels the weight to revolve in a circular path. The centrifugal force exerted through the crank acts in a diagonal direction *c A*. By the principle of the parallelogram of forces, if we let the radius, *c A*, of the crank represent the magnitude of the centrifugal force and construct a parallelogram, *e c b a*, whose sides are vertical and horizontal and drawn through the centers of the shaft *A*, and crank-pin *c*, then the horizontal side *c b* will represent the force required to move the weight *C* horizontally. If instead of being attached to the crank the weight *C* was suspended by a cord *C g*, so that it could swing freely, as shown in fig. 8, and if the crank was at a dead point and the weight was connected to the crank by another cord or rod *C c*, then it is plain that to move the weight horizontally as much pull must be exerted on this rod as must be exerted by the crank in fig. 6. In other words, the resistance of the weight *C*, in fig. 8, to horizontal movement, when the crank is at a dead point, is just equal to the centrifugal force which would be exerted on the crank if the weight was attached to it. When the crank is in the position represented in fig. 7, it has been shown that the force required to move it horizontally is the horizontal component *c b* of the centrifugal force represented by *c A*. In fig. 9 the crank is represented in the same position as in fig. 7, and the weight *C* is again connected to *c* by a rod or cord *C c*. The force required to move *C* horizontally in this figure is the same as that required to move *C* in fig. 7, excepting as it is influenced by the angle of the connecting-rod *C c*, which may at present be disregarded. In other words, the force required to move *C* horizontally is equal to the horizontal component of the centrifugal force of a weight equal to *C* acting at the crank-pin. If, now, we were to put a counterweight *W* equal to *C* and opposite to the crank-pin *c*, fig. 9, then the centrifugal force of *W* would be equal to but would act in a direction, *A W*, opposite to that of *C* in fig. 7. Its horizontal component *e' W*, fig. 9, would be equal to but opposite to *c b* in figs. 7 and 9. Therefore *e' W*, or the horizontal effect of the centrifugal force of the counterweight *W*, will be equal to the horizontal force *c b* required to move *C*, and as they act in reverse directions they will balance each other.

From figs. 6 and 8 it may be observed that when the crank-pin is at the dead point, that the weight *C* is started from a state of rest, and that its motion is accelerated until the crank has made a quarter turn, and that its motion is then retarded to the end of the stroke, or until the crank reaches the back dead point. During the second half of the crank's revolution the movement of the weight *C* is again accelerated during the third quarter and retarded thereafter. The momentum of the weight *C*, acquired during the first and third quarters of the revolution, if not otherwise resisted, will press against the crank-pin and crank, and the reciprocating parts will thus be brought to a state of rest at the end of the stroke by the resistance of the crank. This produces an unbalanced pressure of the crank on one side of the shaft, which has a tendency to push it in the direction in which the pressure is exerted. As the shaft is revolving such a pressure is exerted alternately forward and backward. If, however, there is a counterweight *W* opposite to the crank, the horizontal component of its centrifugal force, as has been shown, is just equal to, and is exerted in the opposite direction to the momentum of the reciprocating parts, and thus balances them, and relieves the shaft of the horizontal disturbances due to the motion of the reciprocating parts.

Now the relation of the weight *C*, in figs. 8 and 9, to the crank is similar to that of the reciprocating parts of an engine, as shown in figs. 10 and 11, in which the cross-head

H is connected to the crank-pin c by the rod $H c$, and the piston-rod r and piston P are attached to the cross-head, and they are all moved together. When the crank is at the dead point, as shown in fig. 10, the force required to move the reciprocating parts horizontally is equal to the centrifugal force of a weight equal to these parts, acting at the crank-pin. Consequently, if we put a counterweight W equal to the reciprocating parts opposite to the crank, its centrifugal force will be just equal to the resistance of these parts and will be exerted in an opposite direction, so that it will balance or counteract the resistance and momentum of the reciprocating parts. When the crank is in any other position, as in fig. 11, then the horizontal component $e' W$ of the centrifugal force of W will always be equal to the horizontal resistance of the reciprocating parts, and they thus balance each other.

The discussion of this subject will be concluded in another article.

NEW PUBLICATIONS.

Almanach des Kriegsflotten (Naval Almanac), 1890: Compiled by the Editors of the *Mittheilungen aus dem Gebiete des Seewesens*. Vienna, Austria; Gerold & Company.

It would be difficult to get information into a more condensed form than in this little book. It is of pocket size—$5\frac{1}{4} \times 3\frac{1}{2}$ in.—and its 220 pages contain what might almost be called a condensed encyclopædia of naval progress.

The book is divided into four parts. The first contains 34 pages of tables convenient for naval officers and engineers, giving the weights and measures of different countries, including sea-miles, knots, etc., tonnage measurement, displacement, and other specially nautical calculations.

Part II. covers 32 pages and gives in tabular form the types and calibers of artillery adopted by the navies of different nations, with tables giving the data obtained by experiment as to power, efficiency, penetration, etc., of different classes of guns.

Part III. contains, in its 110 pages, a list of the ships owned by every country possessing a navy, including vessels under construction. Judging by the section relating to our own Navy, it is evident that great pains have been taken to make these lists as full and accurate as possible, and to bring them up to the latest date. The United States makes a better showing in the list than might have been expected; but a very considerable part of its Navy is still marked as under construction.

The fourth part is made up by 128 sketches of war-ships, showing all the leading types of armored battle-ships in use in the navies of different countries. This part is exceedingly interesting. The engravings are, of course, small, but they are well executed and the subjects are well chosen, giving at a glance the peculiarities of all the principal types of modern battle-ships. The United States is represented here by sketches of the double-turreted monitor *Terror*, the new coast defense vessel *Monterey*, the *Maine*, and the *Texas*.

A convenient addition to the book is a number of blank pages prepared for memoranda and for entry of additional information gathered during the year. The book is in German, of course; for the naval officer conversant with that language no better pocket companion could be found.

The Steam Engine and the Indicator: their Origin and Progressive Development; Including the Most Recent Examples of Steam and Gas Motors, together with the Indicator, its Principles, its Utility and its Application: by William Barnet Le Van. Philadelphia; Henry Carey Baird & Company.

The Author in the opening sentence says that he has endeavored "to explain how, economically, to make use of steam in an engine, and has also discussed the most important principles regarding the *theory and action* of the steam engine, with a fair degree of technicality; and yet so as to be intelligible to the ordinary student."

This opening sentence and others in the book are not models of clearness. There are also some efforts at fine writing, for example the following:

"And to-day, viewing one of the gigantic engines to be seen in some of our large steamboats, who will deny that there is something awfully grand in the contemplation of it? Stand amid its ponderous beams and bars, its wheels and cylinders, and watch their increasing play, how regular, yet how wonderful! A lady's Waltham watch is not more nicely adjusted—the rush of the waterfall is not more awful in its strength. Old Gothic cathedrals and ruined abbeys are solemn places, teaching solemn lessons touching solemn things; but to the contemplative mind, a steam engine can teach a solemn lesson, too: it can tell him of mind wielding matter at its will; it can tell him of intellect battling with the elements; it can tell him of genius to invent, skill to fashion, and perseverance to finish."

"Many men of genius fill obscure graves in whose souls the living fire of poetry, or the bright sparks of genius, lay hidden and lost, merely wanting opportunity or fortuitous circumstances to have enabled them to shed a luster over their race. And in some retired spot, may remain the mortal tenement from which the soul of an Arkwright, a Davy, a Watt, an Evans, or a Webster may have fled, which merely wanted education and opportunities for this development. The fact should be a lesson to those who laugh at novelties and put no faith in further invention, that the mighty steam engine, the triumph of art and skill, was once the laughing-stock of jeering thousands, and once the waking dream of a boy's mind, as he sat, and in seeming idleness, mused upon a small column of steam spouting from a tea-kettle."

Spouting, it will be seen, is not confined to tea-kettles.

The Author objects to the use of the term "energy," and proposes the following substitutes or translations, as he calls them:

ENERGIES.	TRANSLATION.
Plain energy	Power.
Potential energy	Powerful power.
Intrinsic energy	Genuine or true power.
Kinetic energy	Motive power.
Internal energy	Inside power.
External energy	Outside power.
Equality of energy	Alike power.
Factor of energy	Terms of power.
Energy excited	Power that pushes.
Actual energy	Real power.
Mechanical energy	Power in mechanics.

Such work does not require serious criticism.

The book contains a history of the steam engine, which somehow writers seem to think no first-class treatise should be without. It may not be out of place to suggest here that histories of this kind usually occupy a wrong position. The natural way in which we acquire knowledge is not by going back a hundred or several hundred years ago and first finding out what was done then. A boy learns about a locomotive by seeing modern locomotives at work and learning from them what it is that makes the wheels go round. The historical method is the natural method turned upside down. It would in every way be better if the history of an art were given at the end of a treatise instead of at the beginning. It is safe to say

that, if it were reserved for the end, it would be seldom written or read.

Having pointed out some defects of Mr. Le Van's book, it remains to show its merits. The Author has for years been engaged as a mechanical engineer in Philadelphia, and has had an extensive experience in the use of the indicator. Much of the material of the book is evidently drawn from the results of this experience, and has a corresponding value. It deals with problems which every steam engineer must encounter, and discusses them in a way which every engineer can understand. The theoretical discussions thus have a practical flavor which is very agreeable in these days of rarefied speculation.

There is a chapter on the principles of the expansion of steam, and these principles are there very fully elucidated by indicator diagrams, evidently drawn from the experience of its Author. These form, as it were, a series of object lessons which emphasize the explanatory matter, so as to impress it on the mind of the reader in a manner which is easily understood and not easily forgotten.

There are chapters on Gas Engines; Automatic *vs.* Positive Cut-offs, and another containing miscellaneous matter, and an appendix in which are various tables, etc. The style of the book is somewhat diffuse, and the omission of the "fine writing" would have improved it; but even with these faults, it will be profitable reading, especially for young engineers, and, doubtless, for many whose youth is faded into the past.

THE DEVELOPMENT OF THE PHILOSOPHY OF THE STEAM ENGINE; AN HISTORICAL SKETCH: BY ROBERT H. THURSTON. New York; John Wiley & Sons.

This is a republication of a paper which was presented to the British Association for Advancement of Science, at their session held in Montreal in 1884. It is a review of the history of the theory of the steam engine and forms a small book of 48 pages, which will be an excellent guide to any one inclined to study the subject. The usefulness of the sketch would have been increased if the books containing the articles by different authors referred to were always given. It often happens that a reference to the work of an investigator would lead a reader to follow the subject up more fully if he knew where to find what is referred to. Without the title of the book or paper, as much time must be spent in finding what is sought as is required to study the subject.

The republication of his paper by Professor Thurston is timely and will be useful to many readers.

ELEMENTARY BUILDING CONSTRUCTION AND DRAWING: BY EDWARD J. BURRELL, SECOND MASTER OF THE PEOPLE'S PALACE TECHNICAL SCHOOLS, LONDON. London and New York; Longmans, Green & Company.

This book has been written with the idea that, in drawing an object, it is of the utmost importance that the student should understand very thoroughly its construction. The author therefore begins with a short chapter which gives little more than a description of the articles and instruments required in making drawings. The next is on brickwork, and the different methods of laying bricks and constructing walls, arches, etc., are described and illustrated very clearly. This is followed by Exercises thereon which will be understood best by quoting a few examples. Thus the first one is:

"Draw to a scale of $\frac{1}{12}$, figs. 5, 6, 8, 9, 10, and 11, adding in each case an elevation of six courses of the brickwork, an elevation of the returned end, and a section on the line *C D*.

"6. Show about 6′ in length of a dwarf brick wall, 4′ high and 9″ thick, surmounted by one of molded brick copings, illustrated in fig. 34. Front elevation and section to be given. Scale $\frac{1}{12}$.

"10. Draw to a scale of $\frac{1}{4}$, figs. 43 and 44, showing the face arches complete."

The general plan is first to describe the methods of construction and then direct the student how to draw it. There are chapters on Stonework, Wood Joints used in Carpentry and Joinery, Floors, Partitions, Wood Roofs, Slating, Plumbing, Doors, Windows, Notes on Rolled Iron Joists, Cast-Iron Girders, Cantilevers, etc., Iron Roofs, and Materials used in Building Construction.

There are over 300 outline engravings, which are done by some "process" from drawings which were well executed, with the exception of the lettering and figuring, which are very badly done. The book is commended to those who want to study building construction.

THIRD ANNUAL REPORT OF THE INTERSTATE COMMERCE COMMISSION: THOMAS M. COOLEY, WILLIAM R. MORRISON, AUGUSTUS SCHOONMAKER, WALTER L. BRAGG, W. G. VEAZEY, COMMISSIONERS; EDWARD A. MOSELY, SECRETARY. Washington; Government Printing Office.

The Report of the Interstate Commerce Commission for 1889 is made directly to Congress, in accordance with a change in the law, and is, like its predecessors, a document which should receive the careful attention of all who are in any way interested in the railroad problems of the country—and these questions have an interest to every one engaged in the active affairs of life. If space permitted it would be a task which would be pleasant to us to enter at greater length than we are now able to do, into the questions discussed in the report, and to lay before our readers the conclusions and arguments which have been made by the Commission. We can only recommend them, however, to read the report themselves, and they will find that it will amply repay them as an educational exercise.

In the first pages the Commissioners give a statistical statement of the work of the past year, which shows that the positions they occupy are not sinecures, and the further pages of the report, giving the detail of that work in various directions, also show that it has been conducted with an intelligence, a careful desire to reach just and wise conclusions, and a regard for all the varied interests in their keeping, which reflects much credit on the members.

So much must be said in praise; in criticism we hesitate, because the critic is bound to justify his position, and on the points on which it might seem that the report called for such notice it would be necessary to enter into a more extended discussion, and one which belongs rather to the financial than the technical side of railroading. On another page we give some extracts from the report touching upon questions of a technical nature, which we recommend to the attention of our readers.

The Secretary, who, we suppose, is responsible for the "make-up" of the report, deserves the thanks of the readers for the manner in which that really important part of the work has been performed.

BOOKS RECEIVED.

REPORT ON THE INTERNAL COMMERCE OF THE UNITED STATES FOR THE FISCAL YEAR 1889. PART II OF COMMERCE AND NAVIGATION: WILLIAM F. SWITZLER, CHIEF OF THE BUREAU OF STATISTICS, TREASURY DEPARTMENT. Washington; Government Printing Office. This volume of the Internal Commerce Report gives statistics of the commercial, transportation, and other interests of Arkansas, Colorado, Dakota, Kansas, Missouri, Montana, Nebraska, New Mexico, Texas, and Wyoming.

A Text-book on Roofs and Bridges. Part II, Graphic Statics: by Mansfield Merriman, Professor of Civil Engineering in Lehigh University, and Henry S. Jacoby, Instructor in Civil Engineering in Lehigh University. New York; John Wiley & Sons, 15 Astor Place (price, $2.50). This book is received too late for proper examination and review in the present number.

Reports from the Consuls of the United States to the State Department: No. 109, October, 1889. Washington; Government Printing Office.

Reports of Committee on Roads, Read Before the Engineers' Society of Western Pennsylvania. Pittsburgh, Pa.; published by the Society.

Quarterly Report of the Chief of the Bureau of Statistics, Treasury Department, Relative to the Immigration and Navigation of the United States for the Three Months Ending June 30, 1889. Washington; Government Printing Office.

Annual Report of the Postmaster-General of the United States for the Fiscal Year Ending June 30, 1889. Washington; Government Printing Office.

Cornell University, College of Agriculture: Bulletin of the Agricultural Experiment Station, No. XIII, December, 1889. Ithaca, N. Y.; published by the University.

Taylor Iron Works Diary for 1890. High Bridge, N. J.; published by the Taylor Iron Works. This is a new edition of the very neat and convenient pocket diary which these Works have issued annually for a number of years past. The edition for 1890 is an improvement upon its predecessors in several minor particulars, and, indeed, leaves little to be asked for.

Sprague Electric Equipment Company: Catalogue of Electric Railroad Apparatus and Supplies. Chicago, Ill.; issued by the Company.

Hoopes & Townsend's Catalogue of Bolts, Nuts, Rivets, and Kindred Articles. Philadelphia; issued by Hoopes & Townsend, Manufacturers.

Catalogue of Steam Shovels and Wrecking Cars Manufactured by the Bucyrus Foundry & Manufacturing Company: Illustrated. Bucyrus, O.; issued by the Company. This book contains illustrated descriptions and specifications of wrecking cars and steam shovels of various patterns. The Bucyrus Company's machinery is well known to engineers and railroad men; its excellence is attested by the number of its cars and excavators now in use on many different roads, and by the fact that the shops are always busy on new orders. The book is very tastefully printed, and the engravings are good.

Harris Palatial Car Company: Prospectus. Boston, Mass.; issued by the Company. This is an illustrated description of the Harris car, which is a combined sleeping and parlor car on a new plan.

Fine Tools for Accurate Measurement: Illustrated Catalogue and Net Price-List. Chicago, Ill.; C. B. James, No. 98 Lake Street.

ABOUT BOOKS AND PERIODICALS.

The Journal of the Military Service Institution for January contains articles on Mountain Artillery, by Lieutenant Parkhurst; Heavy Artillery Practice, by Lieutenant Foote; Danger from Lack of Preparation for War, by General Gibbon; and several other articles of much interest. There is also the usual variety of selected and translated articles, with the discussions on several papers read before the Institution.

The value of the date palm and the possibility of growing it in California are urged strongly upon the people of that State by S. S. Boynton, in an article published in the Overland Monthly for January.

Two of the most interesting special articles in the Century for January are the short notes on the Care of the Yosemite Valley, and on the Value of Small Colleges.

The December number of the Journal of the New England Water-Works Association contains, besides the reports of the September and December meetings, two valuable papers—one on the Analysis of Water, by Professor Thomas M. Drown; and one on Water-Works Records, by Mr. Albert S. Glover, Water Registrar of Newton.

The second of the well-considered articles on the Merits and Defects of the National Guard, by Lieutenant W. R. Hamilton, appears in Outing for January. Instantaneous Photography, in the same number, will attract the numerous votaries of that art; while all who are interested in outdoor sports and athletic exercises will find abundant material for their reading.

A rare picture of early New York is illustrated in the Magazine of American History for January. In the same number Mr. James W. Gerard—than whom few men know New York better—treats of the Impress of Nationalities on that city in a thoughtful way, which is worth attention.

With the issue for January 4 the journal heretofore known as Building appears with a new heading and with the name changed or enlarged to that of Architecture and Building. The change is an appropriate one, expressing more fully and correctly the full scope of this valuable paper, and the wide field which it covers. At the same time two new departments—Architectural Engineering and Sanitary Engineering—have been added to the paper, both of which may be made of great service to architects.

The Western Railroad Situation meets with more careful consideration than is usual in an article by M. L. Scudder, Jr., in Belford's Magazine for January. Mr. Scudder's conclusions may not all be accepted, but he has a very clear idea of the situation and its causes; the cure for the present evils is yet to be found.

The Russian Army is eulogized by a Russian General in Harper's for January. His account is very interesting, certainly, and no one doubts the excellence of the Russian as a soldier, but a little criticism would, perhaps, have improved the article.

The Chattanooga Tradesman—an excellent and enterprising paper—marks the opening of the new year by an issue of 120 pages, containing a statistical review of the industrial growth and development of the Southern States in the 10 years just closed. The record is a notable one, and will surprise those who are not familiar with the subject. The review has required, evidently, a great deal of careful work, and deserves much credit.

Irrigation is treated of in the Popular Science Monthly for January by Henry J. Philpott. In an article entitled Two and a Half Per Cent., George Iles illustrates the widespread results of the very remarkable fall in the interest value of money which has taken place in the last 20 years.

In Scribner's for January the Household Applications of Electricity are described by A. E. Kennelly. Water Storage in the West is an illustrated article treating of the progress made in irrigating arid lands, which is now attracting so much attention.

CABLE TOWING ON CANALS.

To the Editor of the Railroad and Engineering Journal:

WITH regard to the points emphasized by M. le Chatelier in the paper translated and published in the November number of the JOURNAL, I would like to make some comments.

1. "The boat must be put in motion gradually"—that is to say, it must be started gently and made to take the speed of the cable gradually or by uniform increment of motion. This is a fact, and the condition gives rise, as M. le Chatelier says, to a difficulty. M. Oriolle's devices for overcoming this difficulty are his clutch—fig. 1 of your illustrations—and his spring-winding cone-seated capstan-like snubbing-heads shown in fig. 2. These devices serve the purpose—or are intended to serve the purpose—for which, in my system, I have provided a tow-line with a loop midway of its length—see Patent No. 371,680. This tow-line is to be man-handled by the boatmen through catching a turn of the towing end of the line around a kevel or big cleat fixed on the boat. The snubbing stress on the kevel, being regulated by the boatmen's hands, regulates the grip of the noosed tow-line on the cable. M. le Chatelier says that a loaded boat weighs 400 tons, but the boats on the Erie Canal are not large enough to give that dead weight of boat and cargo. A boat drawing 6½ ft. of water and having 17½ ft. beam, of the general model, very full every way, and 105 ft. in length over all, would displace about 355 net tons. I do not understand that French canal boats are nearly as large as our Erie boats, of which a few carry as much as 280 tons load each; but the favorite size for through traffic is only from 240 to 250 tons. The great hydraulic lift—illustrated in the JOURNAL for March, 1889—recently built in France has a capacity for boats of only about 70 tons; this, however, is by way of parenthesis.

As I was about to say, to start a loaded boat, and thereafter give her a speed of say 2½ miles per hour (or 220 ft. per minute), equal to that of the towing-cable, is an operation hardly to be effected in *one-seventh of a minute*, or while the towing-cable should travel 31.4 ft. only. But if M. Oriolle's spring-capstans are to wind down to a standstill in *nine turns* (as stated), they would pay out only about 17 ft. of tow-line, providing the scale of fig. 2 and of fig. 1 aforesaid is one and the same. But suppose the capstans to be of 18 in. *diameter*, they would, in nine turns, pay out only about 42 ft. of line. At least five times this length of line would go out in the operation of snubbing on. I allow, in my rig, 500 ft. space between stops on my towing-cable. Some such rig as this capstan-gear might, if found desirable, be used as a safety-fast for the tow-rope, to ease up on the tow-line in case of any sudden surge; but for getting a move on the boat the fine hand of the boatman will be the approved instrumentality; he using my grip.

As to the clutch of M. Oriolle, it is of metal, and has projecting arms. How it would pass a cable-carrying roller I do not know exactly. My clutch, or grip, is of braided cord, and has no projecting attachments; it goes through the roller without shock.

M. le Chatelier says: "The cable must be in no danger of leaving the pulleys;" "it must remain strictly underailable." My cable may be made strictly underailable by a certain very simple contrivance devised by me for use in case of need; but with my grip there is no derailing-pull exerted by the tow-line on the cable. When the tow-line passes over my pulley-head the noose, or grip, of the tow-line has reached a position anywhere from 5 to 10 ft. away from (ahead of) the pulley; and there is absolutely no lifting force applied to the cable as it passes over the pulley or roller. Neither is there any lateral pull on the cable caused by the passage of the tow-line over the roller. There is a lateral pull on the swinging part of the towing-cable due to divergence (of about 3°) of line of pull of tow-line from line of travel of cable; but this pull is also downward. Where a clutch or some metallic attachment has to pass the roller (the said clutch at the same time embracing the cable), there will be danger of derailment, except the pulley be made so as to positively bar the cable into the path provided for it; such barring involves use of guard-arms, against which the clutch inevitably strikes.

Of M. Maurice Levy's devices for hitching his tow-line to the cable, M. le Chatelier says: "At short distances apart clutches [shackles] are mounted on the cable, and invariably in position, and these clutches [shackles] carry each a ring to which the tow-rope is fastened by a sort of slip-knot which can be loosened by drawing upon a small cord extending to the boat." M. le Chatelier calls this "a very ingenious and simple way." It is simple enough, but not very ingenious. In order to make attachment of a boat in this way a stopping of the cable has been (thus far) found necessary; as one might reasonably expect it would be. With this rig all easing up or snubbing must be done by some contrivance on the boat, and M. Levy provided no such contrivance, or none is mentioned in any description of his plant that I have seen. Nor is any such contrivance practicably applicable in such service as that contemplated. M. Levy's hitching-on contrivance is, in effect, precisely that suggested by Peter Cooper, the original patentee of driven-cable-towing in 1820. We need say no more of it than simply this: "It won't work."

M. Oriolle's clutch and combined spring-capstan rig is but little, if at all, more applicable to actual service. One may easily say, as M. le Chatelier does: "When the boat is to be attached an attendant puts a clutch upon the cable and fixes the tow-rope to one of the levers; and to the other lever attaches a cord," etc.; and to assume that the tow-rope is then rolled around the spring-capstan, which, offering a continually increasing resistance, duly communicates the cable motion to the boat. But to man-handle a clutch, "composed of an iron box having a lug to which a lever with two arms is attached," and to fix this on the cable, and attach to said arms respectively a cord (one of which is the tow-line), all while the cable is traveling along at the rate of 220 ft. per minute, is an altogether different affair.

The attendant would need to bear a hand very briskly in order to do this fixing inside of one minute, and he would need to do it inside of a minute, because otherwise his clutch would (by the progress of the cable) be brought foul of a cable-carrying roller or pulley. These rollers would be not *more* than 220 ft. apart.

We are not advised as to how the attendant would keep his position with regard to the moving cable while fixing his clutch.

The cable-towing plant of Troll & Mercier, patented in France, November, 1862, has a sufficiently ingenious device in shape of a cable roller, affording safeguard against derailment of cable, but my device (provided for use in case my perfectly plain, round-headed, channeled roller is, in certain situations, not a sufficiently positive guard against derailment) is a much less complicated and less costly piece of mechanism.

Troll & Mercier neither show nor describe any hitching arrangement beyond a simple bending of the tow-line onto the towing-cable. They simply bend on, just as Mr. Cooper simply hooked on, to a ring lashed upon his towing-cable.

M. Oriolle purposes preventing the winding of his tow-line upon the cable, which would result from the spin of the cable (were the line bent on the cable, as Troll & Mercier purposed doing) by an arrangement whereby one of three rings, encircling his cable, is pressed upward and the other two rings drawn downward, with the effect of getting a grip on the cable through opposing stress of the several rings, all free (except for friction of the body of the clutch containing them) to turn with the spin of the cable. The part of the clutch which (through pull of the tow-line) throws the middle ring upward, as aforesaid, is provided with a roller upon which said middle ring turns. The main body of the clutch bears upon the two outer and downwardly-drawn rings which revolve within said body. The mechanism by means of which the rings are made to embrace the cable is not shown in your fig. 1; but, in view of the complicated nature of the clutch device as a whole, we must conclude that the putting of the clutch-rigging upon the cable would occupy the attendant aforesaid considerably more than one minute, even were the cable at rest and were he provided with a stable footing while at work.

I avoid the winding of my tow-line upon my cable by using a cable which does not spin. The Lang cable (composed of strands, the lay of which in the cable is with [not opposed to] the lay of the wires composing the strands respectively) has very little tendency to spin under tension, and would serve admirably for a towing-cable. Because of its proved lasting quality I have purposed using it in my towing-plant. But I have now in view a cable in which there is absolutely *no* spin, which (if it proves equal to its promise in the matter of durability) I shall recommend as preferable to the Lang cable, good as that is.

I do not see that the Oriolle towing-plant is, as a whole, any more thoroughly applicable to canal towing service than is the Levy plant. Neither of these rigs has a practically applicable "grip," and without that all the rest is of but little use.

Each of several inventors in this country has patented a grip (intended for use in towing by means of elevated cable), which is fully as applicable to the service in question as is the Oriolle grip clutch. One grip, devised for use with an endless *bar-chain* towing apparatus, is very ingeniously contrived, and while it is not applicable to service with a cable traveling in simple rollers (because it demands for itself an uninterrupted line of travel), it may be readily adapted to the service of easing up a tow-line in case of sudden and unexpectedly severe strains, or surges, coming upon it, and I intend using something of the sort for the service just mentioned. Any properly applied, screw-adjusted, rope-nipper will suffice for this service. Simplicity is the essential feature in contrivances of this sort. And, in this connection, a final word about the hitching-on arrangement in canal towing by driven cable: The grip or clutch (or whatever it may be, whereby the tow-line is to take hold upon the cable) will, of necessity, be adjustable by one motion of the boatman, or practically that. It will be detachable by means of a pull on a line made fast on the boat. It will have no arms nor levers projecting from it; this because arms, etc., would speedily come to grief in banging against rollers, even if they did not at once tangle themselves with the first rollers encountered, and because when the grip is detached (by pull from boat, as aforesaid) it will drop into the canal if the towing cable travels (as it should) over and along the waterway of the canal; and we do not want in such case a grip which would be also a grapnel, and finally the grip will not be of metal, nor of any material which would render it unmasticable by the cable and rollers, in event of a foul of any sort.

My grip is a simple loop of braided cord, which, were it to get fouled on the cable, would be stripped into shoe-strings by the cable without the slightest detriment to the towing-plant. The grip will cost perhaps 10 cents, not more. Every boat will carry several spare grip-loops. I calculate that a grip-loop will last in service about a week. When worn, replace. Keep a spare tow-line always ready for service. It will now and again be wanted for use as a breast-line, for steering purposes.

Those who care to examine the detail of my towing plant may send for copy of Patent No. 371,680, dated October 18, 1887. I have published a treatise on Cable Towing in Canals, incidentally discussing driven-cable traction generally. This work affords a quite comprehensive view of the subject indicated by the title.

Sharpsville, Pa. J. M. GOODWIN.

A GREAT ENGLISH CRUISER.

(From the London *Engineer*.)

THE first-class twin-screw cruiser *Blake*, which was successfully launched at Chatham recently, is, beyond a peradventure, the most formidable of the "grayhound" series afloat in the British Navy—or, rather, will be so when completed. Mr. White, the Director of Naval Construction, has jumped far ahead of all designs of a similar character now being brought forward, in his plans for the new vessel. While the Italian *Piemonte* has only a displacement of 2,500 tons, although the speed is almost equivalent to that of the *Blake*, the latter possesses no less than 9,000 tons displacement, with the tremendous dimensions of 375 ft. in length by 55 ft. beam, and a draft of 25 ft. 9 in., thus affording a steady platform upon which her guns could be worked without intermission, while lighter cruisers were pitching and tossing around her, and only able to reply with an occasional shot. The *Blake* is 75 ft. longer than either of the belted cruisers. She is constructed of steel throughout, and has a powerfully armored turtle-back steel deck covering the magazines, torpedo-rooms, engines, and boilers, a special protection for the tops of the cylinders being provided in dome-shaped steel shields, which rise above the protective deck. They are from 6 in. to 8 in. in thickness, the protective deck having a maximum thickness of 6 in. in the center, diminishing to 4 in. and 2 in. at the extremities of the vessel. The frame is particularly stout, and so combined with the steel-armored deck as to afford facilities for ramming; 9,000 tons, projected at a speed of 22 knots against an enemy's vessel, would represent an impact that would be irresistible. A large space has been allotted for fuel. No less than 1,500 tons of coal can be carried, which will suffice for a distance of 15,000 knots at 10-knot speed, or 3,000 knots at the ordinary sea speed of 20 knots, expected to be attained. We should have mentioned that the conning-tower is thickly plated with steel, and that special deflective shields will be fitted to the guns, to rotate with them, and entirely cover the breech and gun detachment. It is considered that the 6-in. steel deck-plating will divert a projectile quite as effectually as 12-in. plating of a vertical nature. This, however, remains to be proved. The experiments on the *Resistance* early in the year were scarcely favorable in their results to the importance of turtle decks. The *Blake* has a double bottom, in this respect a vast improvement upon the *Piemonte*.

The machinery, which is being made by Maudslay & Company, will consist of two independent sets of triple-expansion engines of the vertical type, guaranteed to develop 20,000 H. P. with forced draft, and, by means of twin screws, to drive the ship at a maximum rate of 22 knots; with natural draft the horse-power is to be 13,000, and speed 20 knots. As plenty of space has been given to engines and boilers, and the forced draft is not to exceed an air pressure of 2 in. of water, it is probable that the expectations of the manufacturers will be fulfilled.

The *Blake's* armament, as originally designed, was to be two 9.2-in. 22-ton breech-loading steel guns, and ten 6-in. 5-ton 100-pounder quick-firing Armstrong steel guns, eighteen 3-pounder quick-firers, and four torpedo-tubes. But it is doubtful now whether the 6-in. quick-firers will be placed in her, as the size, weight, and length of their projectiles makes them unhandy. The charge and projectile have to be handled separately, and this, to a great extent, neutralizes their value as quick-firers. Moreover, the sealing of the windage in such cases becomes a difficulty, and this has hitherto been found to be insuperable. It is all-important for a quick-firer that the powder-gas should all act toward the muzzle of the gun. Hence, it is probable that the 4.7-in. quick-firing Armstrong steel gun having a projectile of 45 lbs. weight and powder charge made up into a regular cartridge, weighing about 70 lbs., already approved for service both in the Army and Navy, will be employed for the armament of the *Blake*. Four of these guns were mounted in the *Teutonic* at the recent Naval review, and attracted so particularly the attention of the German Emperor that he ordered several of them upon the spot. The 45-pounder has a piercing power up to 12 in. or 15 in. of armor-plate, and 12 shots can be successfully fired per minute from it, only two men being required to work the gun. The 9.2-in. steel breech-loading gun is the most satisfactory of all heavy guns which have been built for some years. It has no tendency to "droop" at the muzzle, has a penetration power up to 18.8 in. of armor-plate, and throws a projectile of 380 lbs. weight at a muzzle velocity of 2,065 foot-seconds. We only regret that any heavier guns should have been constructed; they are perfectly unnecessary.

The *Blake* will cost $1,840,000. She will be employed as a swift cruiser to protect our commerce in the Atlantic

and in Australasian waters, and her speed will enable her to keep pace with any liner afloat. Her sister ship, the *Blenheim*, is now under construction at Blackwall, the Thames Ironworks Company having contracted to deliver her shortly.

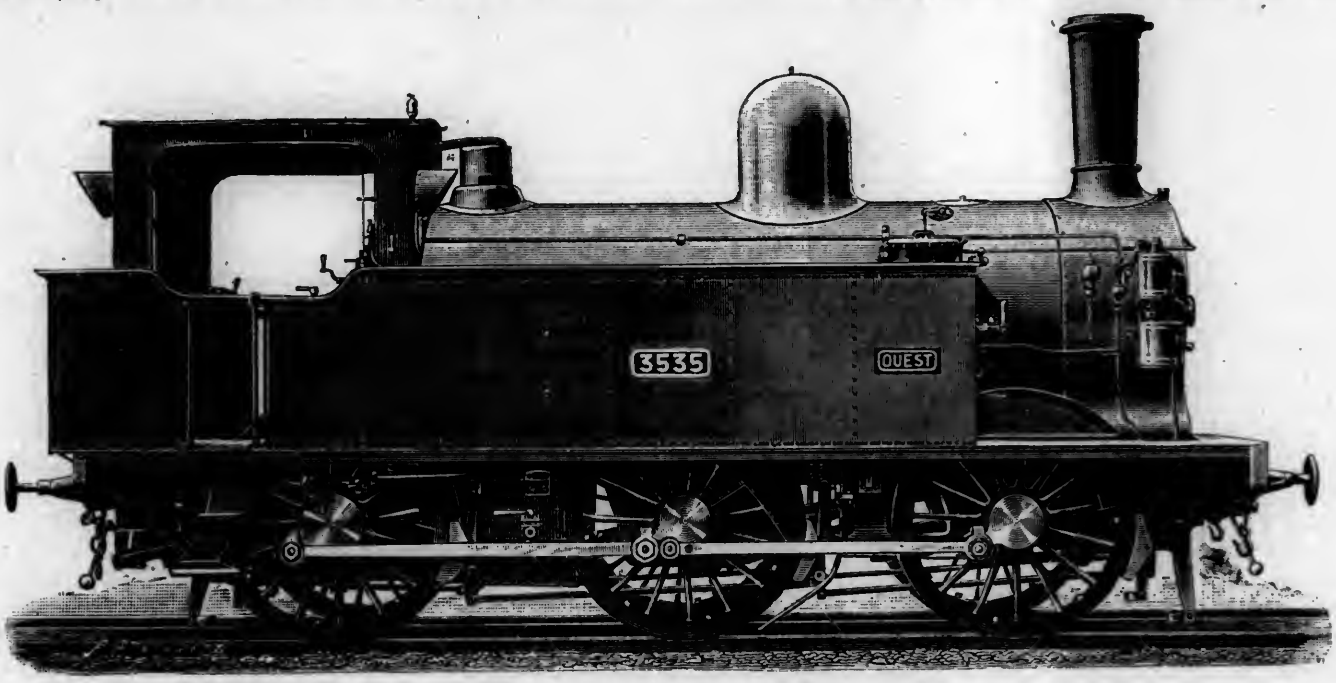
A FRENCH TANK LOCOMOTIVE.

(From the London *Engineering*.)

THE tank locomotive for the Western Railroad of France, of which we give an engraving herewith, is one which was shown at the Paris Exhibition by the builders, the Compagnie de Fives-Lille. The engine is of a type which the Western Railroad Company has used for some years for working local traffic on lines with steep gradients, and it is, as will be seen, a six-coupled tank locomotive with inside cylinders and valve gear. Engines of this type are in use working passenger traffic on the line from Paris to St. Germain, *via* Pecq, which has a gradient of 35 mm. per meter (3½ per cent.) on the line from Paris to St. Germain *via* Marly, where there are numerous gradients of 1 in 66.6; and on that from Paris—St. Lazare to Paris—Champ de Mars *via* Moulineaux, on which there are frequent inclines of 1 in 100.

As regards the line from Paris to St. Germain *via* Pecq, we may mention that from the date of the suppression of the atmospheric system of working up to 1886, the trains were hauled from Paris to Pecq by four-coupled engines, while the part of the train destined for St. Germain was then taken on from Pecq by powerful six-coupled tank engines with wheels 4 ft. 3 in. in diameter. This change of engines at Pecq occupied five minutes, and moreover led to frequent delays, and this, together with other considerations—among them the desirability of running some trains between the terminal stations without intermediate stops—led to the construction of the engines now illustrated, suitable for working trains over the whole route. The chief dimensions of this type of engine are as follows:

Diameter of cylinder	1 ft. 4.9 in.
Stroke " "	1 " 11.6 "
Distance apart of centers of cylinders	2 " 1.6 "
Length of connecting-rods between centers	5 " 8 8 "
Diameter of wheels	5 " 0.6 "
Distance between centers of leading and driving-wheels	7 " 0.6 "
Distance between centers of driving and trailing-wheels	7 " 6.5 "
Total wheel base	14 " 7.1 "
Distance apart of frames	4 " 1.1 "
Total length of engine over buffers	28 " 0 "
Diameter of boiler barrel (mean)	4 " 10 "
Length " " "	10 " 2 "



PASSENGER TANK LOCOMOTIVE, WESTERN RAILROAD OF FRANCE.

Length of inside fire-box	4 ft. 1.5 in.
Width " " "	3 " 4.2 "
Height of fire-box crown above grate	4 " 11 "
Number of tubes	203
Diameter of tubes outside	1.77 in.
Length of tubes	10 ft. 6 in.
Working pressure	142 lbs.
Heating surface: Fire-box	81.8 sq. ft.
" " Tubes	989.2 "
Total	1071.0 sq. ft.
Grate area	14.7 "

The tanks hold 880 galls. of water, and the coal bunkers 2,500 lbs. of coal. The total weight of the engine in working order is 41.5 tons, of which 13.5 tons are on the leading wheels, 13.8 tons on the main driving-wheels, and 14.2 tons on the trailing-wheels.

The boiler has a raised fire-box casing and large dome near the center of the length of the barrel. The boiler shell is of iron, the fire-box of copper (as is also the smoke-box tube plate), and the tubes of brass. The grate is slightly inclined, and the front portion is made to drop.

As in many of the locomotives belonging to the same company, the boiler is enclosed in a sheet-iron air casing which extends from end to end over the smoke-box, and gives the engine the appearance of having a flush-topped boiler. Within this casing the sand-boxes are arranged. The boiler is fed by two No. 9 Friedman injectors, one of the delivery pipes having a branch pipe and cock to which a rubber tube with hose can be attached for the purpose of watering the coal in the bunker. The blast-nozzle is not variable, and is 5.1 in. in diameter.

The frame-plates are of steel, and are 1 in. thick. The buffer-beams are of iron, and the front one is hinged to the frames at its lower edge, so as to give easy access to the front cylinder covers. The cross-connections between the frames are fewer and less rigid than is usual in English practice in engines of a similar type. Thus the only cross-connection between the cylinders and the attachments of the rear foot-plate is that afforded by the motion-plate.

The axle-box guides are of wrought-iron, and each is fitted on one side with an adjusting piece, secured by bolts. The springs for the leading and driving axles are above the axle-boxes, while those for the trailing axle are below. but are arranged so that the end links are in tension. The tires and axles are of cast steel, and the crank-shaft has hooped cranks and a bolt through each crank-pin.

The cylinders are inclined at an angle of 1 in 8⅛, and are placed close together with the valve faces below, so that the valves are readily accessible. The valve-motion is of the Stephenson type, with expansion links of the box pattern, and to accommodate the position of the valves the

motion is transmitted to the latter through rocking levers, as shown in fig. 1.

The pistons are of the Swedish pattern, and are of steel with cast-iron rings. The guide-bars are single and are embraced by the cross-heads, which are fitted with gun-metal wearing faces. The piston-rod packing is metallic, of the Duterne pattern. The eccentric straps are of gun-metal, and the reversing-gear is of the screw type. The coupling-rods are of steel, and their ends are fitted with solid bushes.

The water is carried in a pair of wing-tanks, and the coal-bunker extends across the rear of the foot-plate, as shown. The engine is provided with a hand-brake acting on all the wheels, and it is also fitted with the Westinghouse brake, the air cylinder for which is arranged beneath the foot-plate.

RADIAL VALVE GEARS.

(Paper read before the Hull Institute of Engineers & Naval Architects, by J. R. Smith, Engineer.)

THIS class of valve gear has been known to engineers for about 50 years, but it is only within the last dozen years that altered circumstances and a desire for more perfect results have led to the invention, and in some cases the adoption, of different types of this class of valve gear, seemingly confusing in principle and complicated in details. In order to classify and explain them we will bring before you some of the best-known gears, and would seek to criticise them impartially and in no partisan spirit. To do this I felt it was necessary to consult the original patents, to find out what the patentee really claimed, he, presumably, being at the time a better judge of what was actually included in his patent than either interested parties or partisan advocates.

The list consulted includes 30 patents, the dates varying from 1837 to 1888.

If we look back at the early history of the slide-valve, we find that the single eccentric, working loose on the shaft between two stops, was the commonly-used reversing gear in slow-going land and marine engines, till the higher speed locomotive engine led to the double-gab motion wrought with two eccentrics, fig. 1. It was many years before the spirit of invention suggested the joining of the

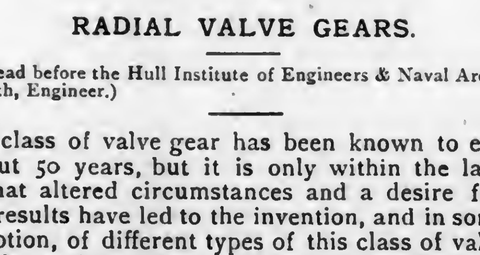


Fig. 1. Cab Gear.

two gabs together, thus leading to Stephenson's slot-link motion. This at once displaced all other reversing motions, the only competitor being the single fixed eccentric, reversed by the spiral sleeve. Mr. Horn, patentee of the condenser wooden ferrules, had a number of engines fitted with this gear about 1860, but you could not "link up" with it, as in the link motion, unless by stopping the engine and piecing on to the driver. Thompson, of Dundee, has revived this style in the small engines made by him.

But inventors were not at rest even after the link motion had displaced the other gears, for we find Punshon in 1839, and Mellor and Hawthorne prior to 1844, working the slide-valve off the connecting-rod. Hawthorne's plan, which was the most complete, is illustrated in Bourne's "Steam Engine," 1846 edition, but it was too complicated to compete with the link motion.

The travel of the slide-valve wrought by a direct link motion is equal to the throw of the eccentric, which by one direct movement causes the valve to travel lap + lead + port opening; but in the year 1859 two clever patents were taken out in this country to do away with the link-motion valve gear, and to accomplish the above motion on a different principle and by different gear; the first by that able and ingenious engineer, J. W. Hackworth, in his Patent No. 2,448, of 1859, the other a French invention showing great ingenuity, but very complicated, by Englemann, of Mulhouse, in his Patent No. 2,864, of 1859. The latter shows one plan of his gear with a single eccentric, fixed opposite the crank with the eccentric-rod, vibrating on a Fink link. Another arrangement was to work off a direct connection to connecting-rod, with compensating levers, but both go on the principle of working expansion and reversion, by shifting not the eccentrics, but

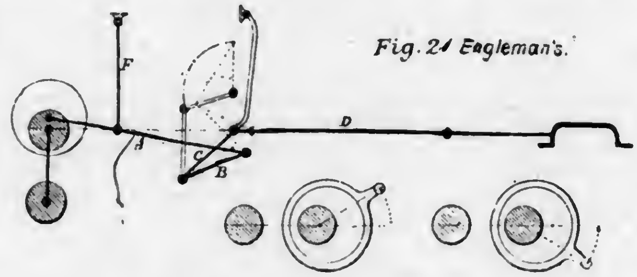


Fig. 2. Englemann's.

the eccentric strap about 30° on each side of neutral line, fig. 2. Englemann claims "The replacing the ordinary sliding block used in link motions by a system of levers and connecting-links jointed together . . . either to produce variations of the expansion, together with the power of changing the . . . rotation of the engine, as shown in the different illustrations."

Hackworth, on the other hand, did away with the working of lap + lead + port opening, by one movement of the eccentric-rod, and as this action has been adopted in most of the other radial gears, the offspring of Hackworth's, we will explain it more fully than those which follow. The principle of Hackworth's gear may be expressed as follows: "In fig. 3, as the point D is constrained to move in paths A, B, or C, so the point E moves in three ellipses, the elliptical paths giving motion to the valve-rod in neutral gear, ahead gear, or astern gear."

At this stage I would draw your attention to fig. 4, which may be called Hackworth's complex gear, and the principle of which is illustrated in his specification. If we make $B\,z$ horizontal it is evident that the point E receives no motion from the traverse of the point D, but only from the vertical throw of the eccentric through point F, the point V being so placed in lever $f\,d$ that the motion of the valve would be equal to lap + lead. But to obtain port opening (or, strictly speaking, the "remaining port opening," and so throughout this paper), the point D must re-

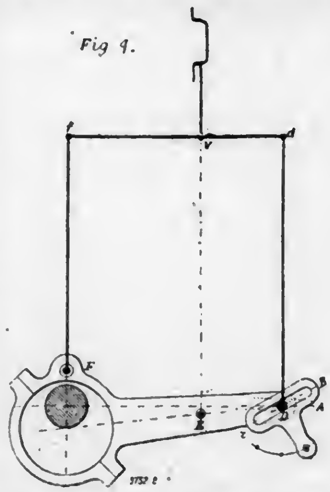


Fig. 4.

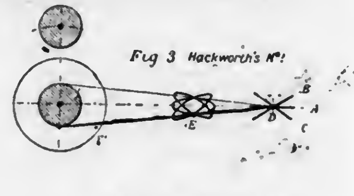


Fig. 3. Hackworth's No. 1

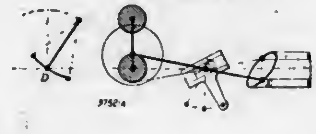


Fig. 5. Hackworth's No. 2.

ceive a motion which will cause it to rise and fall; this is got by angling $B\,z$, as shown in the engraving, and so we see that in Hackworth's gear the travel of the valve is produced by the component motion of the vertical travel of rods $F\,f$ and $D\,d$. Let us now eliminate the three rods $F\,f$, $f\,d$, $d\,D$, and connect the valve-rod direct to the eccentric-rod by one rod $V\,E$, and we have Hackworth's gear as patented by him in all its simplicity, an expansion reversible valve gear not only having fewer working parts than Englemann's or other previous gears, but also as few as any other gear since invented to attain the same ends.

In the gear wherein the fulcrum is at the end of the eccentric-rod, which is a lever of the second order, as he explains and illustrates it, wrought by a radius-rod suspended from the valve-rod side of eccentric-rod, see fig. 3, *B* gear, which is the first example of a radius-rod applied to a lever of the second order, Hackworth claims "The arrangement and combination of the machinery for deducing two motions from one eccentric, one motion for working the lap and lead of the valve, and the other at right angles with this, whereby I obtain variable expansion and reverse motion. And other 10 claims of arrangement and combination of machinery as set forth," etc.

Hackworth took out a patent for his second gear in No. 4,246, of 1876, in which he makes the eccentric-rod a lever of the first order, by altering the position of the fulcrum *D*, and working the valve-rod off the end of the lever; this gives a better elliptical motion to the point *E*, and enables you to get a given travel of valve with a less throw of eccentric, and makes the valve decidedly quicker in its action than in No. 1 gear. But with these benefits it has this serious disadvantage, that while in the first gear the load on fulcrum-pin *D* is never much over the load on the valve-rod, in this his second gear with eccentric-rod a lever of the first order, the load on the fulcrum-pin is nearly twice the load on the valve-rod.

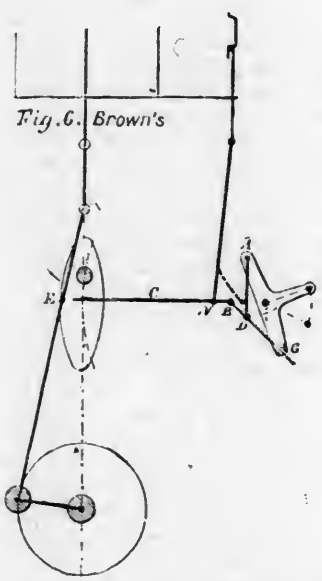


Fig. 6. Brown's

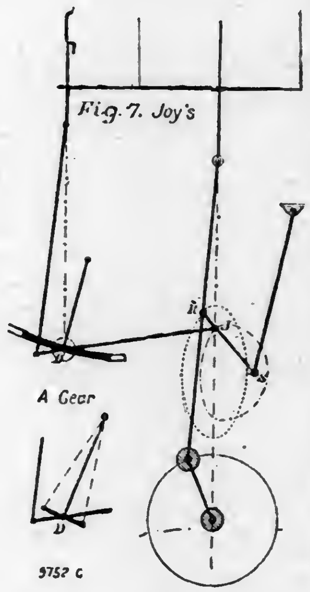


Fig. 7. Joy's

He states that the two right-angled movements cause the valve to open quickly on turning the center, which is immediately followed with partial suspension of motion, the two actions neutralizing one another, and claims, "Increased expansion of steam is obtained by connecting the valve-rod to the extreme end of the eccentric-rod." Fig. 5 illustrates this second gear, in which you will observe the difference of the elliptical path compared with fig. 3. In both these gears the point *D* is on the same plane as the center of the shaft when the eccentric is at the top or bottom centers, no matter whether in neutral, ahead, or astern positions, so it follows: 1. That this gear gives constant lead top and bottom for all degrees of expansion; also 2. That we have equal port opening top and bottom; and 3. That the slow and quick periods are extended longer than if the path of *E* had been a circle instead of elliptical. One objectionable feature in Hackworth's gear (more noticeable in No. 1 gear) is that it necessitates a long angular traverse motion to give a short vertical motion.

The egg-shaped oval described by a point in the complete sweep of the connecting-rod, during a full revolution, would be a tempting project, if it could be made to work Hackworth's principle of expansion and reversion instead of an eccentric, but it requires no great perception to see that whenever we attach direct to the connecting-rod we introduce an error, owing to the major axis of the oval being a straight line, while the radius of the vibrating lever is an arc of a circle (see fig. 6), so that unless we make the vibrating lever infinitely long, the fulcrum point will traverse unequally on each side of the neutral point; so all gears working off the connecting-rod must have some compensating means to correct this evil, and this compensation is the basis of most of the patents of connecting-rod radial gear.

Brown, of Switzerland, in his Patent No. 5,175, of 1878, was the first to work the Hackworth class of gear off the connecting-rod, and this he did by connecting direct on to the rod, but compensating by his compound radius bars *A D*, *B G*, fig. 6. He made a great many locomotives for Swiss, German, and other railways; usually these were fitted with a rocker between the piston-rod and the connecting-rod, but in our illustration we have shown this gear applied to a marine engine, and for simplicity we have shown the valve-rod attachment as placed by Brown to suit his rocker engines; but this being done away in our application, the valve-rod would require to be bent to dotted lines, and the vibrating lever made one of the first order. It will be seen that the rod *C*, attached direct to the connecting-rod at the point *E*, swings from point *A* by connection with the radius-rod at the point *D*, causing the point *B* to describe an angular line, slightly curved, and gives motion to the valve-rod by means of the elliptical motion described by point *V*. The point *B* is the important point to watch in this gear, and the rod *B G*, when in motion, swivels and slides at the same time through the center *G*. The radius of the rocker, *L*, even assists to equalize this gear. Brown describes his gear as one of the class known as Hackworth's, and claims "The arrangement of parallel motion for correcting the error of valve-gear radius-rod, and also for correcting the error produced by the curved path of the vibrating lever."

Joy, in his Patent No. 929, of 1879, on the other hand, does not connect his vibrating level to the connecting-rod direct, but ingeniously introduces a compensation lever *R S*, fig. 7, and connects the vibrating lever to the same at the point *J*, which is the most interesting point in Joy's gear, for while the point *R* describes an oval whose major axis is a vertical straight line, the point *J* describes a flattened ellipse, the major axis of which is the versed sine of the vibrating lever, thus causing the fulcrum point *D* to have a motion equal and symmetrical.

Joy utilized Hackworth's No. 2 gear, but with the sliding path altered to a curve equal to the radius of the valve-rod; but he also described, and in some cases uses, a radius-rod swinging from the valve side of the vibrating lever, and which is the first example of a radius-rod applied to a lever of the first order (fig. 7).

Advocates of the link-motion and single-eccentric gear take exception to Joy's curved slot "sliding-block" surface, but it compares favorably with single-eccentric gear (as Marshall's) or link-motion with two eccentrics, where the rubbing surfaces of Joy's sliding block, compared with the eccentric surfaces of the two gears named, would be per revolution as 1 : 3 and 1 : 5.

This is the best-known radial gear, and over 1,000 locomotives working in this and other countries, as well as 35 war vessels and over 100 merchant steamers, have been up to date fitted with it, although marine engineers, while conceding that it is one of the best gears, have fought rather shy of it, thinking it rather expensive to make.

Joy claims "The use, for the purpose hereinbefore mentioned, of a lever coupled and having its motion governed in the manner described in specification."

Further on, in 1879, Bremme took out his Patent No. 2,037, for "Improvement in Steam and other Steering

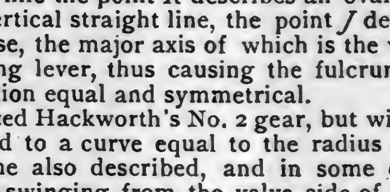


Fig. 8. Bremme's

Gears," in which he used Hackworth's second gear, but with the fulcrum point swinging on a radius-rod, this being the fourth example of the use of the radius-rod, and the second example of its application to a lever of the first order, but this he applied the opposite way to that

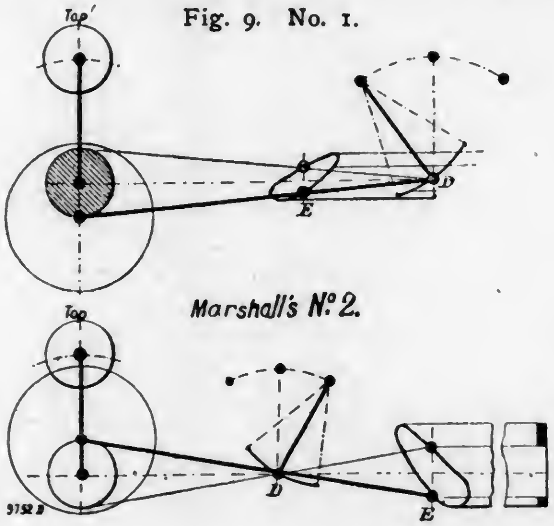
shown by Hackworth in 1859, by Brown in 1878, and Joy in 1879, in their respective gears. Bremme's gear, copied from his specification, is shown in fig. 8, and he claims "Sixthly, reversing gear constructed and operating as substantially set forth."

From the illustration you will see the excessive difference between the port opening top and bottom in this gear, to remedy which Bremme made no provision in his patent.

As Bremme's patent rights and rather bold claims have been much advertised and criticised of late, the Author would state his conviction, that while Bremme's specification was the first to show the radius-rod attached to Hackworth's No. 2 gear wrought by an eccentric, yet he was not the inventor of the radius-rod attachment (Hackworth's 1859 gear had it), neither was he the first to apply it to a lever of the first order, for Joy had included this, so that Bremme is tied down to his own design of gear "constructed and operating as substantially set forth," but which is never made; at least in the Author's experience he has never seen one.

In 1879 and 1880 Marshall took out his patents for the gears which are now known by his name; these two gears introduce us to the radius-rod gears as now usually made; the first one, fig. 9, was really illustrated in Hackworth's 1859 specification, and Marshall honestly acknowledges this to be a modification of Hackworth's, but finding out the inequality of port opening due to the mean inclination of the curved path being less under the neutral point than

Fig. 9. No. 1.

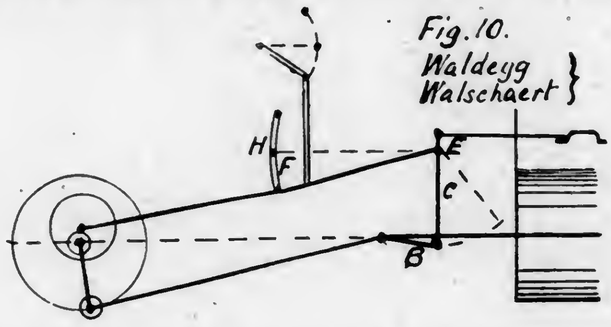


above it (see difference in fig. 9), thus making the valve travel unequal, he corrected the same by means of an extra port opening. This also applies to the No. 2 gear. These two radius-rod gears, as mechanical arrangements, have the advantage over the two original sliding-block gears, working with circular surfaces instead of sliding surfaces, the former requiring less surface per unit of load and being easier to adjust, although the extraordinary wear got by Joy out of his sliding blocks has revived, in an example yet to be given, the old sliding-block system of Hackworth. On the other hand, considered as steam distributors, Hackworth's has the advantage of equal port openings at the top and bottom of the valve, while the radius-rod system has the advantage of equal cut-off top and bottom.

What we stated, when comparing Hackworth's No. 1 and No. 2 gears, is true also in these two gears, and Mr. Milton has shown that with the gear a lever of the first order (fig. 9, No. 2), the strains are nearly 2½ times more than in the No. 1 gear, and Bremme in his printed circulars states that the load on the radius-rod should be reckoned 2½ times that on the valve-rod. This is quite in keeping with the practical experience of those of us who have had to do with overhauling or repairing No. 2 gear, and Mr. Marshall himself states, "That the strains in working (No. 2 gear) were so great that the advantages were more than counterbalanced by the risks attending its adoption." Of course extra large surfaces and the use of piston-valves would help, but we can never get over the fact of the greatly-increased strain the one gear has compared with the other.

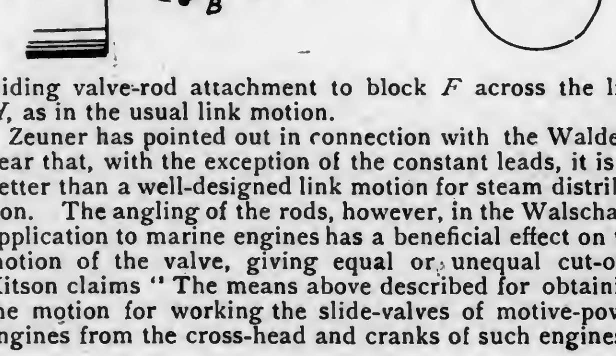
Marshall, who fits this style of gears almost exclusively, has done more than any other engineer to bring them into repute; he claims, in his 1879 patent, "The combination of mechanism constituting the valve gearing, consisting of eccentric and strap, having a valve lever suspended from an arm on reversing shaft by a radius-rod, arranged and operating substantially as shown and described; also the use of dissimilar ended valves of the common slide, the Trick slide, or cylindrical construction."

In Kitson's Patent No. 4,612, of 1879, we are introduced to another class of valve gear, a modification of the well-



known "Waldegg gear," so much used in the Belgian locomotives under the name of the "Walschaert gear." Many of us are familiar with Kitson's, seeing it on the Hull & Barnsley dock locomotives. The original Waldegg gear is simply a link motion whose neutral axis is a fixed center, wrought by one eccentric, which moves the valve through the port opening, a further motion of lap + lead being given to the valve by a connection from the piston-rod cross-head. Those who saw the Belgian State locomotives shown at the late Paris Exhibition would observe the latest example of the Walschaert gear, and it is identically the same as what we have described as the original Waldegg gear.

Kitson does away with the eccentric motion, but still uses a circular motion received from the crank-pin, and instead of using the vibrating link he uses a bell-crank link. Fig. 11 shows this gear applied to a marine engine, and fig. 10 shows the Walschaert gear as fitted to the same by Messrs. Ramage & Ferguson, of Leith. It has also been fitted by Napier, Denny, and others, in the Clyde District. As you will observe, in both of these gears the piston-rod connection moves the valve through its lap + lead, while the eccentric in the Walschaert and the throw from the crank in the Kitson gives the port opening. The method for accomplishing expansion and reversion is by



sliding valve-rod attachment to block F across the link H, as in the usual link motion.

Zeuner has pointed out in connection with the Waldegg gear that, with the exception of the constant leads, it is no better than a well-designed link motion for steam distribution. The angling of the rods, however, in the Walschaert application to marine engines has a beneficial effect on the motion of the valve, giving equal or unequal cut-offs. Kitson claims "The means above described for obtaining the motion for working the slide-valves of motive-power engines from the cross-head and cranks of such engines."

(TO BE CONTINUED.)

WATER-TUBE BOILERS.

(Abstract of paper read before the Institution of Civil Engineers, by W. I. Thornycroft.)

WATER-TUBE boilers are those in which the water to be evaporated is contained within the tubes which form the heating-surface. In 1878 Mr. Flannery, in a paper contributed to the Institution, showed what progress had been made up to that date with this kind of boiler at sea. That communication, and the discussion which followed, proved that although considerable saving of fuel had been obtained with them, water-tube boilers as then made were unsuitable, because the tubes forming the heating-surface were burned, owing to insufficient circulation. The Author, therefore, commenced by discussing the kinds of circulation in various forms of tubulous boilers, arriving at the conclusion that circulation, in order to be perfect, must be systematic, under which condition a smaller amount of water could be successfully used and the weight of this element thereby reduced. By circulation, he intended to convey the idea of motion of the water contained in a steam generator, from the upper surface of the liquid down to the lower part of the generator, and returning again to the upper surface. Motion of water, simply from the point where the feed-water was admitted to a point in the boiler where it became steam, he wished to hold distinct from the idea of circulation. Having thus defined the term, the Author divided all boilers into classes, depending on the manner in which circulation took place. The first type dealt with was described as the oldest and simplest form of boiler, in which circulation at the outset depended upon small variations of density in its different parts. The action might be energetic when boiling took place, but was wanting in order, being struggling and confused in character, and nowhere acquiring high velocity. The circulation of the earliest water-tube boilers was of this nature. The Author then described the boilers of Mr. Perkins, Mr. Herreshoff, M. du Temple, and Mr. Matheson; and also gave an account of the Field tube. The boilers of the *Peace* and of the *Propontis* were compared, and the most suitable diameter and length of tube were discussed. The Author attributed the failure of the upper ends of the tubes of the *Propontis* to their being of such large diameter that, instead of steam and water passing over in foam, steam alone left the tubes, and all impurities brought in with the feed-water gradually accumulated in the upper part of the tubes, and ultimately led to their destruction. He thought it possible that obstruction from sediment collected in this manner gave rise, at a later period, to the more serious failure of the large water chambers. He next showed that a water-tube boiler might be constructed of less material than one of the ordinary form, and that this result was partly due to the fact that a strong envelope only was required to surround the steam and water, which must necessarily be enclosed in a pressure-resisting shell. In the case of the ordinary form of boiler, there was a strong vessel containing not only the steam and water, but likewise the fire and the products of combustion. These latter, it was pointed out, were again enveloped in a second or inner shell, and thus were covered twice by material to resist the whole pressure contained in the boiler. This was shown to be one evident cause of the great saving of material possible with the water-tube system. The reduction in weight was accompanied by greatly superior steaming power, economy of fuel, and less forcing of the fires. Lastly, the safety of the vessel and crew had been materially increased. The conditions favorable to perfect combustion, and those which tended to satisfactory absorption of the heat from gases produced, were then described, together with a boiler which the Author had designed with a view to embody the principles of circulation and of combustion which appeared to him to be the best. Lightness of structure and strength to resist internal pressure had been particularly kept in view, and the evil effects of unequal expansion had been provided for by the curved form of the tubes, which afforded practically the whole heating-surface. These tubes were shaped so as to make an arch over the fire, only allowing escape for the products of combustion by a series of narrow openings a little above the surface of the fire. In the upper portion of the arch each tube, by touching its neighbor, formed a continuous roof, and enclosed a large space above the firebars extending the whole length of the boiler. The tubes which composed the fire-box having arrived at a point near the center of the arch, altered their direction of curvature, and after meeting, turned apart again to give room for the largest vessel in the boiler. By keeping in contiguous lines they afforded a protection from the heat to this vessel. In a similar way in which the furnace was formed, two rows of tubes united to make the external casing of the boiler, at the same time constituting a flue in which numerous other tubes were placed. The ends of all these tubes were secured in three horizontal cylinders, two of which served the purpose of supplying water to the tubes. The third was a separator, from which the steam produced was taken and the overflowing water returned to the tubes. For this purpose large external tubes connected the separator to the cylinders forming the base, and between these cylinders the firebars were arranged with a firebrick bridge on either side, protecting the cylinders from excessive heat. The fire-doors were situated at one end of the tunnel or arch of tubes, and the other end was closed principally by blocks of light fire-resisting brick inclined away from the fire to add to their durability. The water-level in the boiler was best a little below the center line of the separator, in which was placed, underneath the points where the tubes entered, a shield, to guide the circulating water down to the water-surface, at the same time protecting from spray a perforated pipe, in which the steam was collected. The ends of the boiler were covered with plating, and in order to make the casing quite smoke-tight, the outer wall of tubes was also covered with light plating; but this had not to resist any great heat. The first water-tube boiler, put into a torpedo-boat by the Author's firm, afforded a very satisfactory means of comparison between the new boiler and its locomotive rival, which had been placed in a sister vessel. The result of steaming was eminently satisfactory, and the saving in fuel at equal speeds was sufficiently evident without exact experiment, the boat under natural draft being about 1 knot an hour faster than the other vessel, the full-power trials showing also a difference of 0.67 knot speed in favor of the former. Some evaporative trials were made by the Portsmouth authorities, and the results seemed to indicate that equal duty could be obtained when the proportionate quantity of water evaporated was 2.36 from the water-tube boiler to 1.00 from the locomotive boiler. After this boiler had been at work for three years, several tubes were cut out with the view to ascertain their state. They afforded a sample of tubes under varying conditions. Some were taken from the fire-box where they had been exposed to the full intensity of the heat, and some from positions in the flue where the heat was much less. Their condition was eminently satisfactory. The small amount of scale in their interior was a great contrast to the condition of water-tubes taken from the boiler of the *Propontis*, in which the circulation was not so well provided for; the thickness of the tubes had suffered no perceptible diminution. The Author then gave the results of some recent trials made by Professor Alexander Kennedy—whose report was appended to the paper—both with natural draft and with different amounts of forced draft, and a full description was given of the method of conducting them. At the most economical rate of working, the evaporation, reduced to standard, amounted to 13.4 lbs. of water per pound of fuel, and the following heat-balance showed the way in which the heat of the combustion was utilized by the boiler:

	Per cent.
Heat expended in heating and evaporating feed-water	86.8
Heat expended in raising temperature of furnace gases	10.8
Heat lost through formation of carbonic oxide	0.5
Heat lost by radiation and otherwise unaccounted for	1.9
	100.0

The very high percentage of evaporation—86.8—represented the efficiency of the boiler, and was simply equal to the ratio between the actual evaporation and that theoreti-

Fig. 2

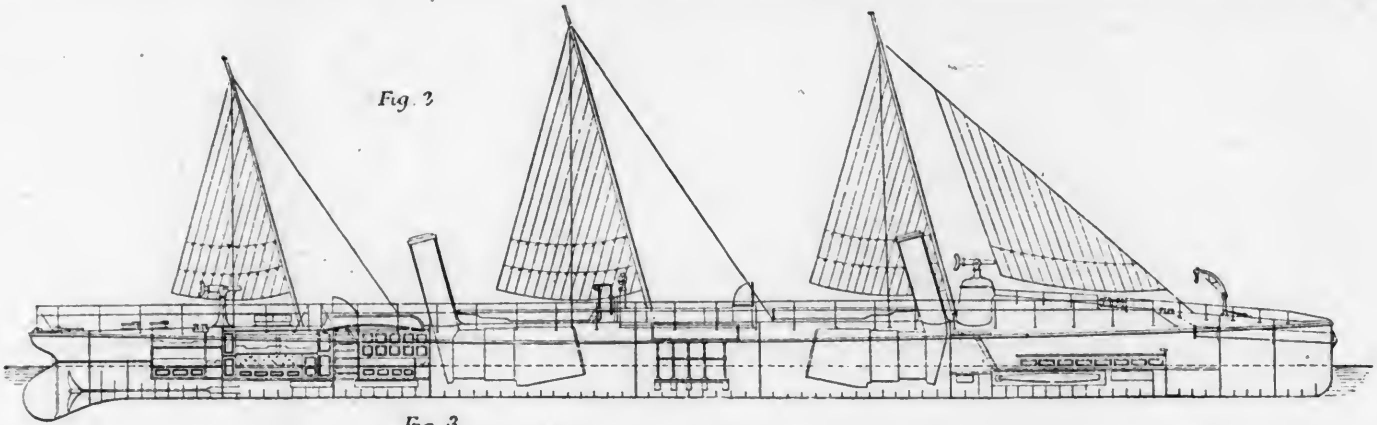


Fig 3.

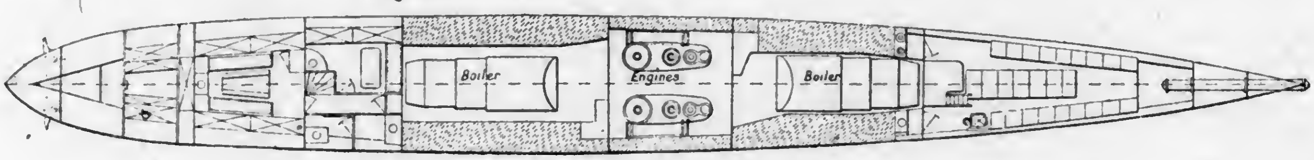


Fig 4

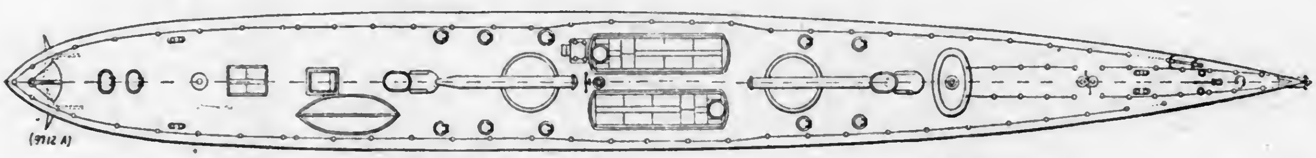


Fig. 6. Wave line at 14 Knots

Fig. 7. Wave line at 18 Knots.

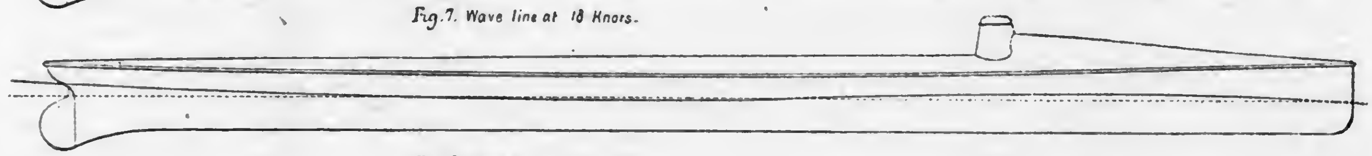
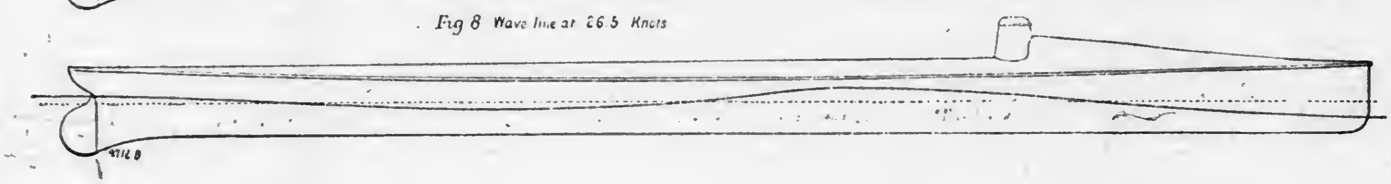


Fig 8 Wave line at 26.5 Knots



13 Atm Boiler pressure. 0.91 Vacuum. = 13·37 lbs. Fig. 5.
325 Revols per minute. 17" Stroke.
Dia.r Cyl.r 17" - 26" - 37"

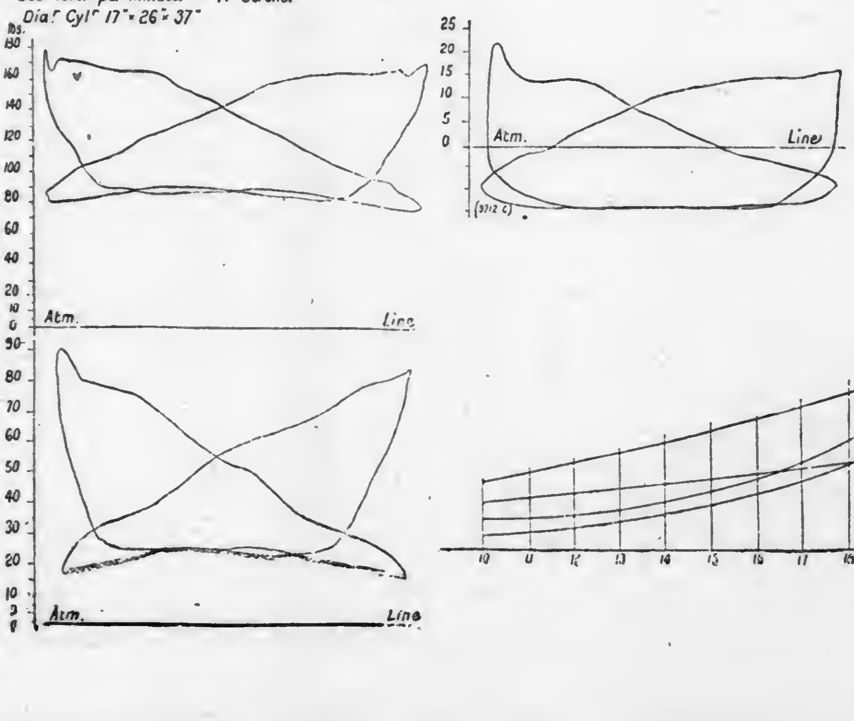
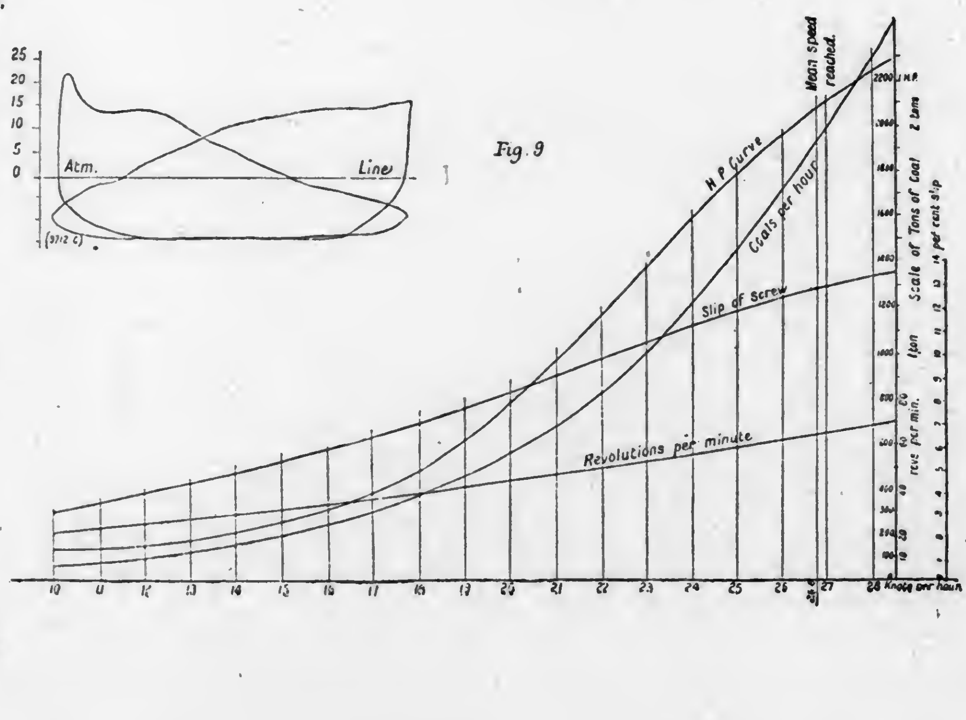


Fig. 9



cally due to the perfect combustion of the fuel, or 13.4 : 15.4. This is believed to be the highest boiler efficiency on trustworthy record.

The fact may be added to the statements in the paper that water-tube boilers are to have a test in practical working in the United States Navy.

TORPEDO BOATS FOR THE ITALIAN NAVY.

(From the London *Engineering*.)

AMONG the oldest, and certainly among the most successful of the Continental builders of torpedo boats must be classed Mr. F. Schichau, of Elbing, Prussia. Mr. Schichau has not been content simply to follow in the footsteps of the two leading English builders, but he has proved a most formidable rival; and, indeed, in some cases, it must be confessed, the English builders have followed the lead of the Elbing yard.

We have at various times previously illustrated some of Mr. Schichau's boats, and we are now, through his courtesy, able to place before our readers fuller particulars of some of his most successful craft. The remarkable speed attained by these vessels renders the data especially valuable, and English naval architects and engineers will be interested in following the results obtained.

The accompanying illustrations show a twin-screw torpedo boat built by this enterprising firm. The engravings represent one of five sister vessels built to the order of the Italian Government. Their names are *Aquila*, *Sparviero*, *Nibbio*, *Falko*, and *Avoltoio*. The following particulars of these vessels have been supplied to us: They are 46.5 meters long (151 ft. 8 in.) and 5.2 meters wide (17 ft.) The draft of water is 2.3 meters (7 ft. 6 in.). The hull is divided into 12 water-tight compartments, there being also longitudinal bulkheads. The vessel will continue afloat if all compartments forward of the boiler are filled with water.

Each vessel is fitted with two locomotive type marine boilers with 1,700 sq. ft. of heating surface, and two sets of triple-compound engines. The latter are placed amidships, while the boilers are placed fore and aft, the propeller shafts passing at the side of the after boiler. The cylinders are 17 in., 26 in., and 37 in. in diameter by 17 in. stroke. The total horse-power developed by the engines is set down at about 2,200 indicated; the boiler pressure is 13 atmospheres, and the air pressure in stoke-hold 30 mm. to 40 mm. (1.18 in. to 1.58 in.). The propellers are three-bladed and of 1.8 meters diameter (5 ft. 11 in.). There are auxiliary engines for electric light, steam steering gear, and an air compressor for torpedo discharge for the bow tube, the tubes on deck ejecting their torpedoes by powder. The boiler and engines are entirely enclosed by the coal bunkers, as shown in our illustrations. There is also an electric signal apparatus. The three torpedo tubes are arranged as shown in the engraving, the complement of torpedoes carried being six. There are two Hotchkiss guns. The coal bunkers have a capacity of about 40 tons, with which these vessels can steam for a distance of 5,000 miles at 10 knots speed. All compartments have large bilge ejectors, which together can discharge 800 tons of water per hour. The displacement of the boats, fully equipped and with full bunkers, is 160 tons. The displacement during trial was 145 tons. The details of the trial displacement were as follows: Boilers and engines, with water, etc., 61; coal, 14; torpedoes, munitions, etc., with 24 men, 7.5; vessel, guns, electric engines, signals, masts and rigging, 62.5; total, 145 tons.

The trials of these boats were made in the Baltic, near Pillau, the course being defined by fixed landmarks placed 19 miles apart. Each boat ran at full power for three hours, and the following results are given:

Aquila, tried July 28, 1888. Strength of wind, 4, with strong running sea; mean speed, 26.2 knots.

Sparviero, tried August 6, 1888. Wind, 3; mean speed, 26.6 knots.

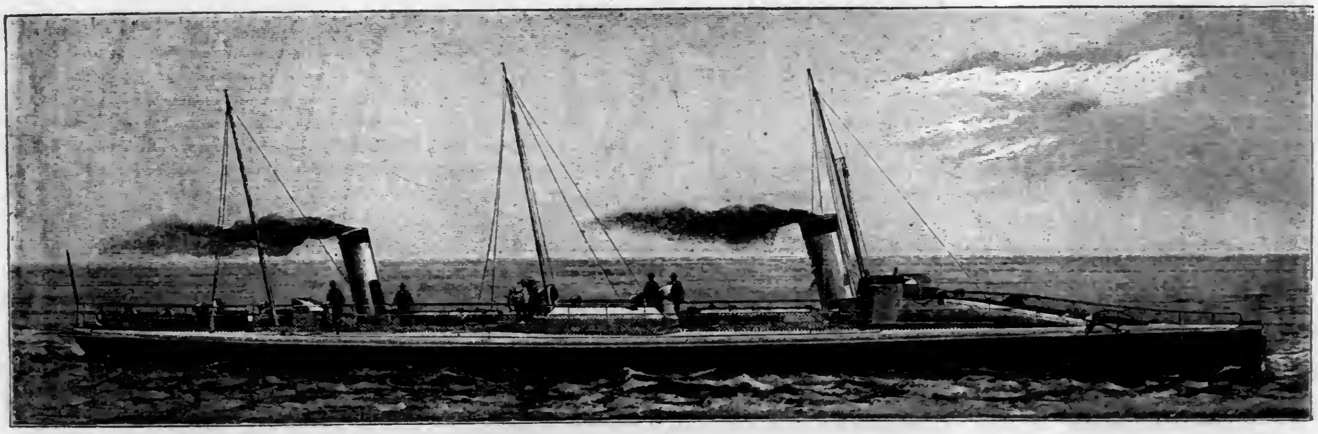
Nibbio, tried August 22, 1888. Wind, 2; mean speed, 26.8 knots.

The horse-power is stated to have been about 2,000 indicated, and the engines worked without any hitch at an average speed of from 320 to 325 revolutions per minute. The boats are said to have turned in a circle of 300 meters by using the twin screws.

In the illustrations, fig. 1 is a general view of one of these vessels. Figs. 2, 3, and 4, are respectively a longitudinal section, a plan with deck removed and a deck plan of the same vessel. In fig. 5 we give indicator diagrams taken from the engines of the *Aquila*, which well repay careful examination. The boiler pressure was 13 atmospheres and the vacuum 13.37 lbs. The revolutions were 325 per minute. These diagrams must have been taken at full speed, as they work out very nearly the 2,200 indicated H.P. given as the power required for full speed. Figs. 6, 7, and 8 show the wave line of the *Aquila* and sister vessels when running at 14, 18, and 26.5 knots speed respectively. In the diagram, fig. 9, are given curves showing coal consumption, indicated horse-power, slip of screw, and revolutions at speeds varying from 10 knots to 28 knots per hour.

The following details are given of five other boats built for the Italian Navy: 39 meters long (128 ft.) and 4.8 meters wide (15 ft. 9 in.); draft, 2.2 meters (7 ft. 2 in.); displacement, fully equipped, 85 tons; engines of triple-compound type, developing 1,200 indicated H.P. The contract speed was 21.5 knots during a three hours' run at sea. The actual speed obtained was 22.5 knots. We presume this was the best out of these five boats.

The ten boats made the passage from Elbing to Spezia, and encountered rough weather on the way. They all, however, arrived safely, making the run in short times. At the present time there are building at Elbing, besides some 30 other vessels, one twin-screw boat for the Russian Government, with a guaranteed speed of 26½ knots, and five of the same type for other orders.



FIRST-CLASS TORPEDO BOAT FOR THE ITALIAN NAVY.

THE ABT RACK-RAILROAD.

In previous numbers of the JOURNAL—for November, 1888, page 442, and for January, 1889, page 12—reference has been made to the Abt rack-rail system for mountain railroads, which experience has so far shown to be the best yet tried for working steep inclines by locomotive power. The following account of the latest locomotive for a rack-railroad, with some account of the experience gained on such a road, is condensed from a paper read before the Technical Railroad Union in Berlin recently by Herr Schneider, Director of the Harz Mountain Railroad, one of the first lines built on Herr Abt's plans :

It will be remembered that one of the distinguishing features of the Abt system is the arrangement of the rack-rail. This consists of three plates or bars of steel laid on the ties, in the center between the ordinary rails, the teeth being cut on the upper edges of these plates, which are held place by chairs of appropriate form, spiked to the ties, and in are set at a distance apart from each other about equal to their thickness. In setting the teeth are stepped by each other one-third of their pitch, and the pinions which work in them are made to correspond. Owing to the thinness of the rack-plates, they are easily bent to correspond to any curve in the track.

At points where the rack-rail begins or ends—that is, where the transition is made from the rack-railroad to the ordinary adhesion-railroad—a short section of the rack is connected by a hinge-joint, allowing it to move vertically. This section is supported by springs, allowing the pinions to enter on the rack, and the teeth to enter into gear without shock.

The rack-bars used on the Harz Mountain Railroad are 0.78 in. thick, 4.33 in. deep, and 8.65 ft. long ; they are of Bessemer steel. In laying they are always placed so as to break joints.

As a part of the line only is on the rack-rail system, the locomotives are adapted to work on this system or on an ordinary track as desired. The latest engine built for the road, which includes the improvements shown by experience to be desirable, is shown in the accompanying illustrations, fig. 1 being a longitudinal section ; fig. 2 a half-plan, showing the running gear ; fig. 3 a half-section through the fire-box ; fig. 4 a half-section through the smoke-box ; fig. 5 a cross-section, showing the rack-rail and pinions. The dimensions on these cuts are in meters.

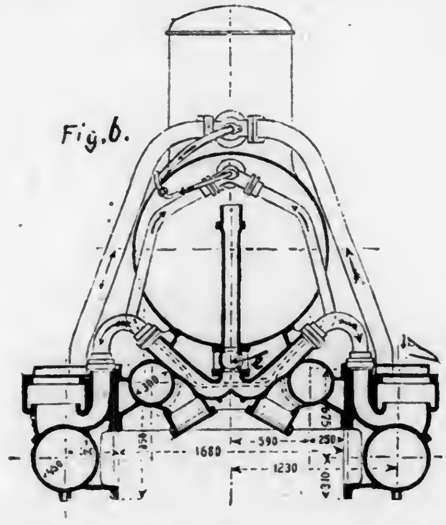
This locomotive may, in fact, be said to consist of two separate engines served by one boiler and carried on one set of frames.

Considered as an ordinary or adhesion locomotive, it is a tank engine having outside cylinders, three pair of driving-wheels, coupled, all in front of the fire-box, and a Bissell truck back of the fire-box. The total driving-wheel base is 10 ft., and the distance from center of rear drivers to center of truck is 7 ft. 10.5 in. The driving-wheels are 49.2 in. and the truck wheels 29.5 in. in diameter. The cylinders are 17.7 in. in diameter and 23.6 in. stroke. The frame is of the plate type generally used in Europe. The pedestals carrying the driving-boxes are secured to the frame by angle-irons ; between the boxes and the pedestals of the rear and middle axles only the usual play is allowed, but the boxes of the forward axle have additional play, in order to allow the wheels to accommodate themselves to the sharp curves, and to prevent too much flange-wear. The center of the radius-bar of the truck is 4 ft. 7.1 in. from the center of the axle.

The boiler barrel is 54.33 in. in diameter and 13 ft. 3.4 in. long. The fire-box is 5 ft. 6.9 in. long and 3 ft. 7.3 in. wide. The heating surface of the fire-box is 89.4 sq. ft. ; tubes, 1,374.4 sq. ft. ; a total of 1,463.8 sq. ft. The grate area is 19.4 sq. ft. The usual working pressure is 150 lbs. The center of the boiler is 7 ft. 10 in. above the level of the rails.

The only peculiarity in the boiler is the double throttle placed in the dome. One of these valves admits steam to

Fig. 6.



the steam-chests of the ordinary cylinders, the steam-pipes being carried down outside the boiler, as shown in figs. 1 and 4 ; the other admits steam to the rack-rail cylinders, the steam-pipes passing through the smoke-box.

The total weight of the engine in full working order is 55 tons, of which 43 tons are carried on the driving-wheels

Fig. 7.

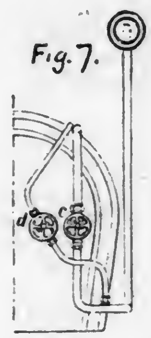
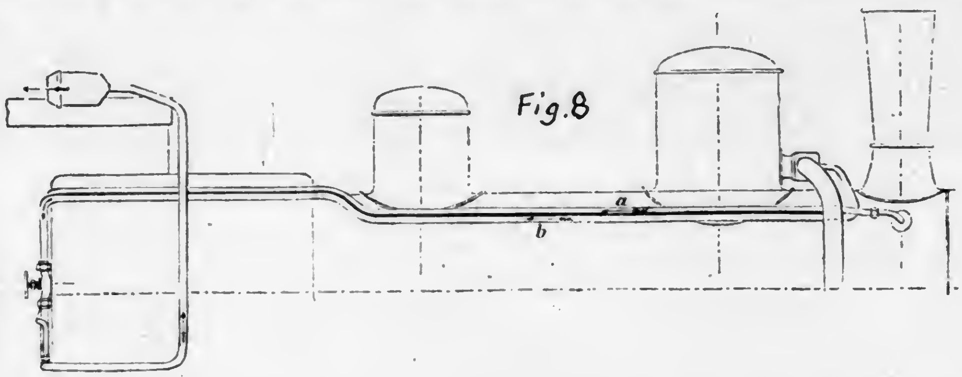


Fig. 8



and 12 tons on the truck. The tanks will hold 1,750 gals. of water, and the coal bin about 4,400 lbs. of coal.

The second or rack-rail engine consists of the two pinions which gear in the rack-rail, and the two inside cylinders placed in the smoke-box. These cylinders are set at a considerable inclination, and have the steam-chests underneath, as shown in fig. 4 ; they are 11.8 in. in diameter and 23.6 in. stroke. The pinions are 22.56 in. in diameter to the pitch line and are carried each on an axle or shaft of its own. The teeth on these pinions are 4.72 in. pitch, and they are made in three sections, to match the triple rack.

The cylinders of the rack-rail engine are necessarily set high, in order that the connecting rods may clear the main axles. These connecting rods act upon rocker arms keyed on an independent axle carried in bearings upon the main frame, as shown in figs. 1 and 5. From the shorter arms of these rockers a connecting rod runs to crank-pins on the outer ends of the rear pinion shaft. The two pinion shafts are coupled by parallel rods, as shown in fig. 2.

The pinion shafts or axles are carried by two plate frames, which are carried by the main driving axles, as shown in fig. 2. By this arrangement the pinions are kept always at the same height, and the relative position of the pinions and the rack-rail is not affected by the motion of the locomotive on its springs.

The link-motion for the valves of the rack-rail cylinders is worked from eccentrics on the main or rear pinion shaft. The valve-motion for the main cylinders is outside the driving-wheels.

The rack-rail cylinders are cast with flanges on the outer side, through which they are bolted both to the frames and to the main cylinders; the latter being cast with long flanges inside for this purpose. This arrangement, which is shown in fig. 4, makes a very solid job.

Originally the exhaust pipes from both sets of cylinders were led into a single exhaust nozzle, which was provided at the top with an arrangement of the Polonceau type for varying the area of the opening. It was found, however, that when both engines were working, and were not running evenly together, the exhaust steam from the adhesion-cylinders would be drawn into the rack-rail cylinders, interfering with their proper working; moreover, the blast was irregular and the fire would get into bad condition. To remedy this a new exhaust nozzle was put on, with separate passages for each set of cylinders. This at once removed the trouble, and the steaming qualities of the boiler were so much improved that 15 tons could be added to the train without diminishing the speed.

The engine is provided with the ordinary screw-brakes, the brake-shoes acting on the driving-wheels. There are also brakes working on brake-wheels or disks attached to the pinions; these can be applied by a brake-wheel or lever placed on the fireman's side of the cab, as shown in fig. 1. Besides these two brakes there is also an arrangement by which air can be admitted to the cylinders and, by its compression in them, used as an additional brake power. This is shown in figs. 6, 7, and 8. In figs. 7 and 8 *a* is the air-pipe and *d* the air-escape valve from the rack-rail cylinders; *b* the air-pipe and *c* the air-escape valve from the large cylinders. These are so arranged that the engineman can use the brake power of either pair of cyl-

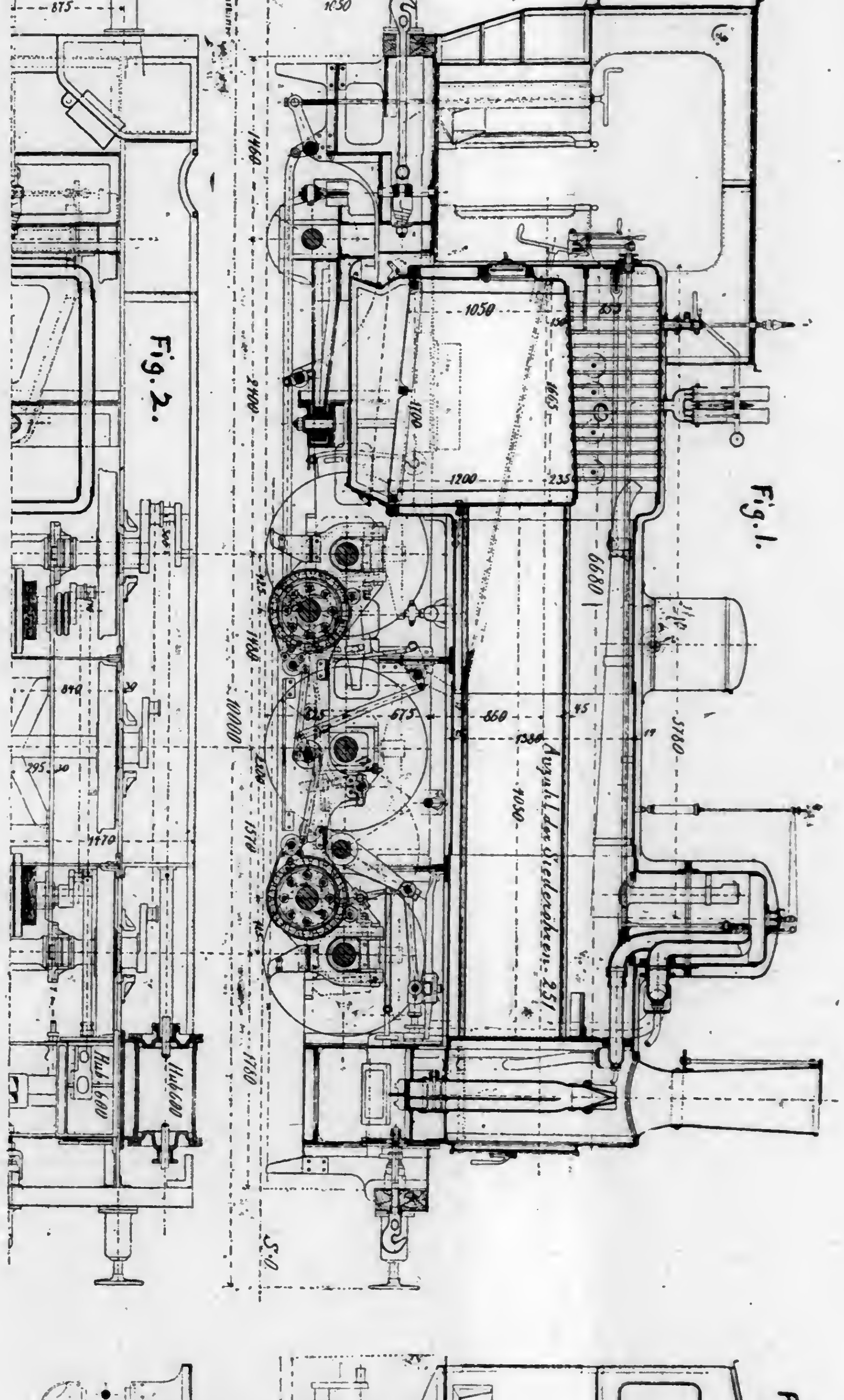


Fig. 1. Fig. 2.

LOCOMOTIVE FOR THE HARZ MOUNTAIN RAILROAD, ABT RACK-RAIL SYSTEM.

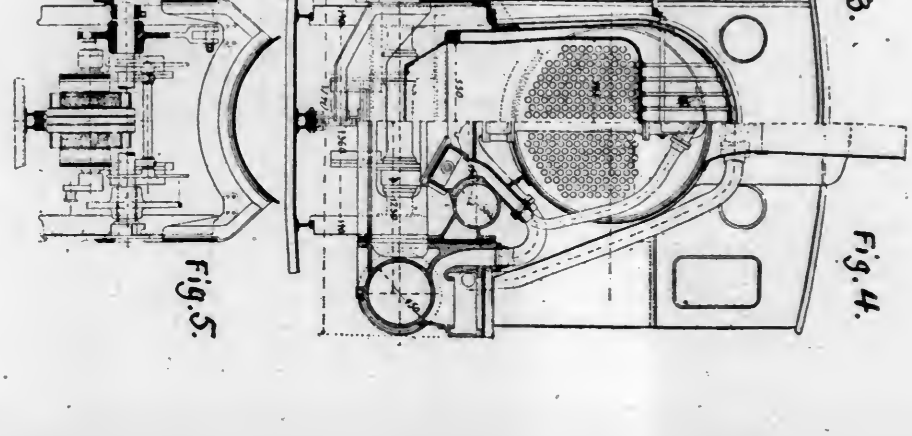
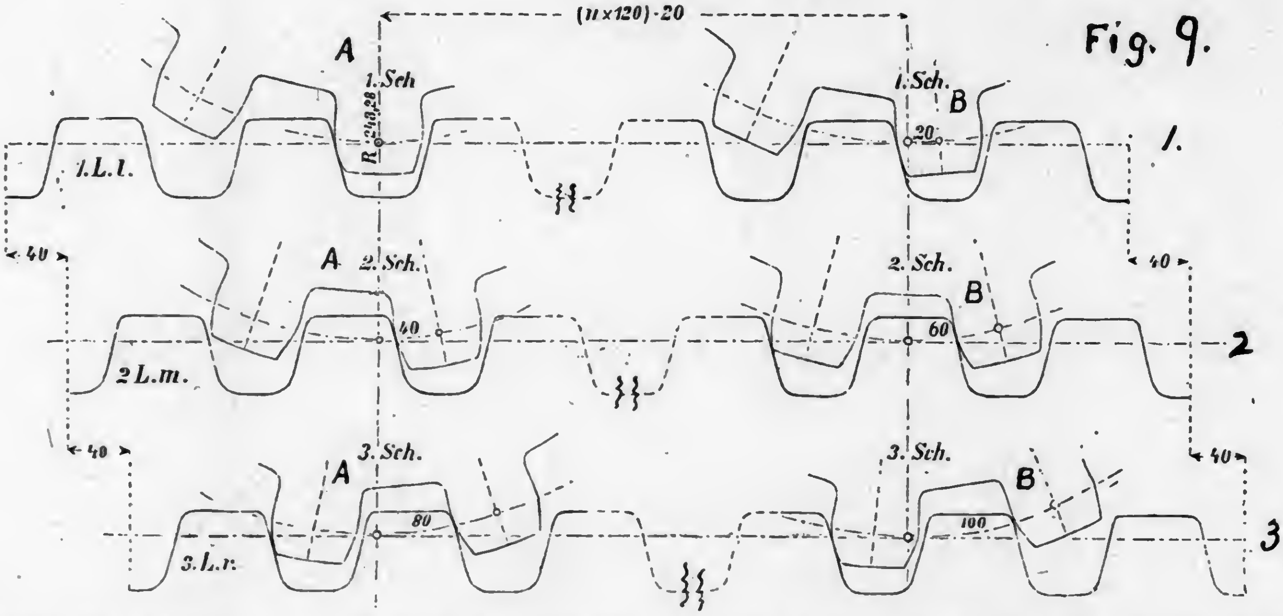


Fig. 3. Fig. 4. Fig. 5.

inders separately, or of both at once. The air is admitted by a valve under the smoke-box, shown at *e*, fig. 6. Cold-water pipes are provided, running to both sets of steam-chests, to prevent too great heating from the compressed air.



In practice it is found that the brakes on the engine are quite sufficient for the ordinary stops, and the brakes on the train are kept as a reserve, to be applied in emergencies.

Fig. 9 shows the relative position of the pinion teeth and the teeth of the triple rack when the rack-rail is in use. In this figure *A A A* are the sections of the pinion on the main axle, and *B B B* those of the pinion on the coupled axle, showing the position of the teeth on the sections 1, 2, and 3 of the rack respectively. From this diagram the reason for the arrangement of the triple rack will be readily seen. The bearing is so distributed over the teeth that there is no possibility of too great a strain being thrown upon any one tooth at any time, and danger from breakage of a tooth is avoided. Even should one break, the strain will at once be taken up by the others, and being distributed over several, there will be no sudden shock to any one tooth.

With regard to the wear of the teeth upon the rack-rail something is shown by fig. 10, which is a section (full size) of a tooth from a pinion on the locomotive *Brocken*, which had been in use, in regular service on the road for four years. In this figure the outer lines *a a* show the original profile of the tooth; the middle lines *b b* the profile after four years' service; the inner lines *c c* the extent to which the tooth can wear before the pinion must be replaced. The full black portion on either side, between the lines *a a* and *b b*, is the amount of metal worn away in four years; the heavily shaded portions, between *b b* and *c c*, the amount of metal which can still be worn away before the pinion is thrown aside. In practice it has been found that the wear of all the teeth on the same pinion is nearly uniform.

Fig. 11.

It may here be repeated that the diameter of the pinions to pitch line is 22.56 in. ; over all, 24.13 in. ; pitch of teeth, 4.72 in. ; width of teeth when new, 2.205 in. The wear after four years was about 0.158 in. on either side, at

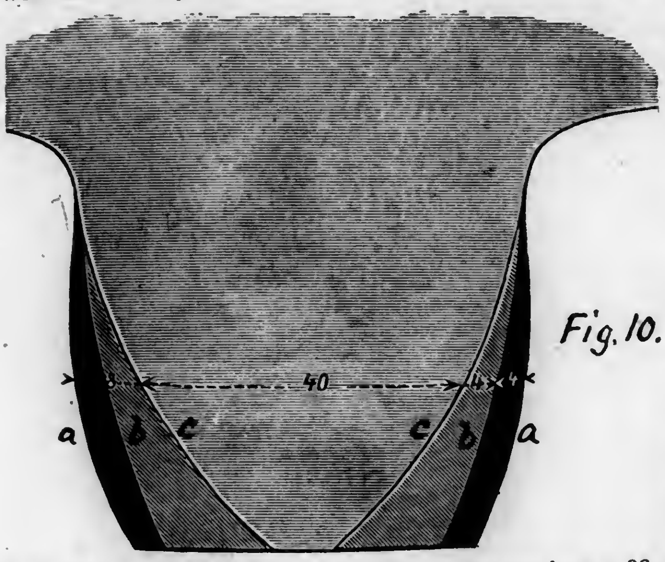


Fig. 10.

the widest point, reducing the width of the tooth to 1.889 in.

In running these locomotives it must be remembered that the engine-driver has, in fact, two separate machines under his charge. In addition to the care demanded from the driver of an ordinary engine, he has, therefore, to watch for the proper times for making the transition from the rack-rail engine to the adhesion engine, and *vice versa.* On the Harz Mountain Railroad, at each point where the rack-rail begins, double signals, designated as *A* and *B*, are provided. These indicate to the engine-driver the points where the throttle should be opened to admit steam to the rack-rail cylinders and where the other throttle should be closed, to shut off steam from the adhesion-cylinders. Of course, in leaving the rack-rail the process is reversed.

An average train on this road consists of a passenger car, a baggage car, an "outlook car," and four to five freight cars. The cars—both passenger and freight—are all four-wheeled cars.

Of the three remaining illustrations fig. 11 shows the beginning of a section of rack-rail on the Harz Mountain Railroad near Rübeland ; fig. 12 a bridge on the same road


Fig. 12.

near Rothehütte, and fig. 13 a view on the road on the Eichenberge near Blankenberg. For these engravings we are indebted to Gläser's *Annalen für Gewerbe und Bauwesen.*

It may be mentioned that to remedy an occasional hard-running or grinding of the spur-wheels which was observed, the experiment was tried of greasing or lubricating the rack-rails once a week ; the inside of the outer rails on the sharp curves was also lubricated to prevent the cutting or grinding of the car-wheels. This simple expedient proved entirely sufficient to do away with the trouble.

The service on the Harz Mountain Railroad is carried on winter and summer without difficulty. In the last two winters, when the snow at times was over 3 ft. deep, the rack-rail proved the best assistant in keeping up the service, and the delays to traffic were very slight.

The latest application of the Abt system is on the Trans-Andine Railroad, which is now under construction as part of the great transcontinental line which is to connect Buenos Ayres on the Atlantic Coast of South America with Valparaiso on the Pacific. Here the adoption of this system in crossing the Andes has enabled the engineers to adopt much higher grades, reduce the amount of tunnel-

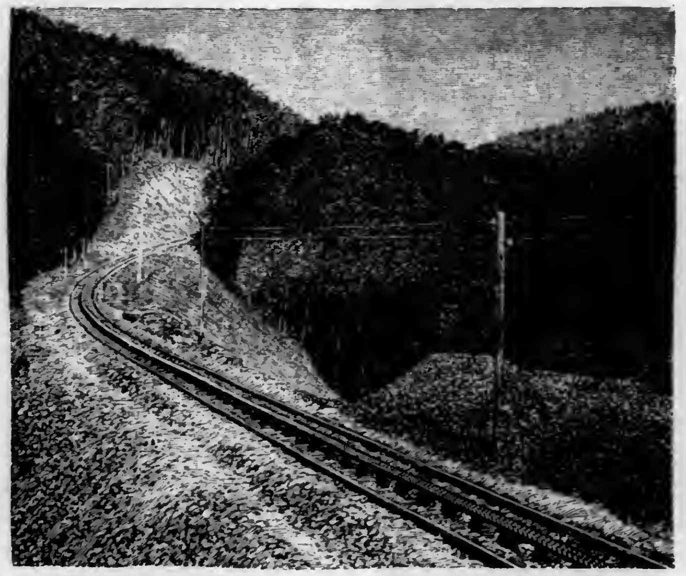


Fig. 13.

ing and other heavy work, and in this way to diminish considerably the cost of a very difficult piece of mountain railroad.

THE FORTH BRIDGE.

So much has been published about the history and construction of the Forth Bridge, that any recapitulation would be superfluous, but as the bridge is now practically completed, a general description may be of service.

The bridge proper is 5,349 ft. 6 in. in length, and consists of two cantilever spans resting upon three piers, each pier being made up of a group of four cylindrical piers of masonry, each carrying one of the iron towers which form the support of the cantilever. In the central span the tubular columns are 260 ft. apart and the cantilever arms project 680 ft. on each side, making the total length 1,620 ft. In the two others the columns are 145 ft. apart, the cantilever arms project 680 ft. and the shore or anchor arms 689 ft. 9 in., making the total length of each 1,514 ft. 6 in. The two suspended or connecting spans are each 350 ft. in length. As constructed this gives two main spans, each of 1,710 ft. clear, with a clear height above high water of 150 ft. for a length of 500 ft. in one span and of 850 ft. in the other. The span above is made up of the two projecting arms, each 680 ft., and the suspended span, 350 ft. ; total, 1,710 ft.

The approach on one end consists of one truss span of 173 ft. ; three of 168 ft. each, and one of 179 ft. On the other end there are 10 truss spans : One of 173 ft. ; then eight of 168 ft. each, and one of 179 ft. The general ar-

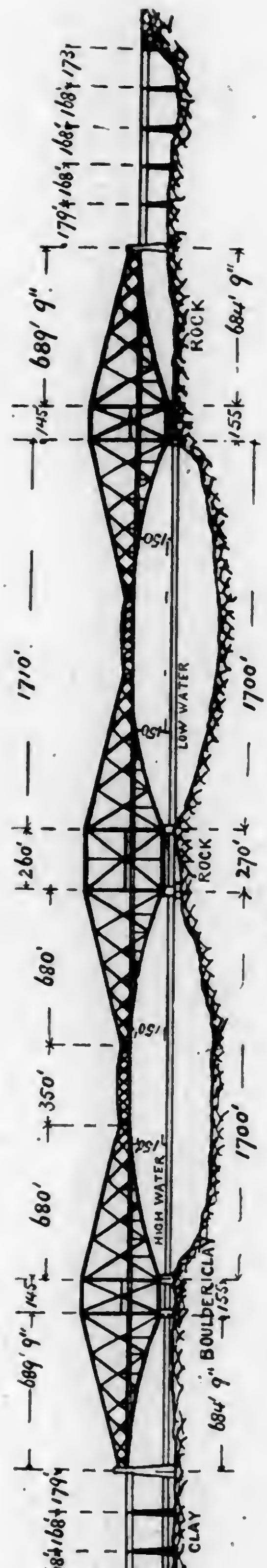


Fig. 1.

SKETCH OF ELEVATION OF THE FORTH BRIDGE.

rangement of the bridge is shown in the accompanying sketch.

The cantilevers are 343 ft. deep over the piers and 40 ft. at the ends. The bottom members consist of a pair of tubes tapering in diameter from 12 ft. to 5 ft., and spaced 120 ft. apart, center to center, at the piers, and 31 ft. 6 in. apart at the ends.

In the illustration fig. 1 is a general elevation ; fig. 2 a cross-section of the cantilever at the pier ; fig. 3 a cross-section at the center ; fig. 4 a cross-section of the roadway on a much larger scale ; fig. 5 a section of the upper tension member ; fig. 6 a section of the lower compression member.

The top members consist of a pair of box lattice girders tapering in depth from 12 ft. to 5 ft., spaced 33 ft. apart at the piers and 22 ft. 3 in. at the ends. Each tube has a maximum gross sectional area of 830 sq. in., and each girder a maximum net sectional area of 506 sq. in. Upon each cylindrical masonry pier is bolted a skew-back, from

CROSS SECTION AT CENTRE

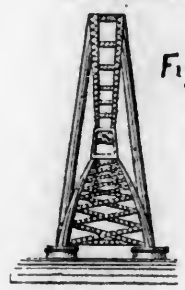


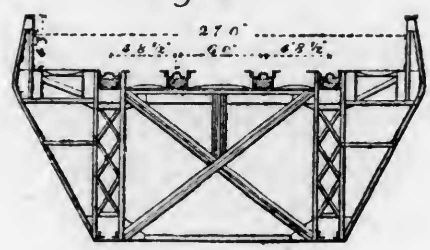
Fig.3.

CROSS SECTION AT PIER

Fig.2.

CROSS SECTION OF ROADWAY

Fig 4.



UPPER TENSION MEMBER

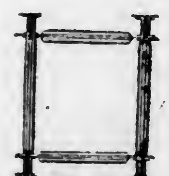


Fig.5.

BOTTOM COMPRESSION MEMBER.

Fig.6.

which spring vertical and diagonal columns and struts. The former are 12 ft. in diameter and from 368 to 468 sq. in. in sectional area ; the latter are flattened tubes. Horizontal wind-bracing of lattice girders connects the tubes forming the bottom members of the cantilevers, and similar vertical wind-bracing connects the vertical and diagonal tubes, so that the whole structure is a network of bracing, capable of resisting strains in any direction and of any attainable severity.

The rolling load provided for is : 1. Trains of unlimited length on each line of rails, weighing one ton per foot run. 2. Trains on each line made up of two engines and tenders, weighing in all 142 tons, at the head of a train of 60 coal-trucks of 15 tons each—that is, 1,042 tons total train-weight.

The wind-pressure provided for is a pressure of 56 lbs. per square foot striking the whole or any part of the bridge, at any angle with the horizon, the total amount on the main span being estimated at no less than 7,900 tons. In practice, only two trains, weighing 800 tons in all, would be

on this length of bridge at one time, so that the wind-pressure—if such a hurricane as would produce a pressure of 56 lbs. to the square foot should come—would be nearly 10 times as great as the train-load.

Under the combined stresses resulting from the test-load in the worst position and the heaviest hurricane, the maximum stress on the steel will not exceed 7½ tons per square inch on any portion of the structure, and on members subject to great variations in intensity and character of stress, the maximum will not exceed 4 tons per square inch. For tubular columns and struts 34 to 37-ton steel, with an elongation of 17 per cent. in 8 in., was specified: for tension members, 30 to 33-ton steel, with 20 per cent. of elongation.

The contract for the bridge was let in December, 1882, to the firm of Tancred, Arrol & Company—a firm specially organized for this contract—the price specified being £1,600,000. The bridge has thus been nearly seven years under construction. Some of the greatest difficulties experienced were in sinking the great 70-ft. cylinders for the piers. The structure is built throughout on the English plan, with riveted joints.

The bridge carries the North British Railway across the Forth, the total expenditure of over $8,000,000 having been undertaken to shorten the distance between Edinburgh and the North of Scotland, by avoiding the long circuit previously made by the railroad. The construction of a bridge was first proposed in 1865, and various plans were submitted before the design now finally carried out was adopted. This design was the work of Sir John Fowler and Mr. Benjamin Baker.

NATIONAL REGULATION OF RAILROAD SAFETY APPLIANCES.

WE give below the greater part of the remarks contained in the third annual report of the Interstate Commerce Commission on this subject:

Personally concerned as every man is in the safety of travel the subject of railroad accidents has always had the greatest popular interest. That the facts are quite sufficient to warrant this interest may be seen from the following figures taken from the annual reports of the railroads of the country made to the Commission for the year ending June 30, 1888. There were reported for that year deaths and injuries to persons as follows:

Passengers killed	315
Passengers injured	2,138
Employés killed	2,070
Employés injured	20,148
Other persons killed	2,897
Other persons injured	3,602
Total persons killed	5,282
Total persons injured	25 888

But the reports do not cover the total mileage of the country; only 92.792 per cent. of it. If the accident rate was the same on the roads not reporting, the total number killed was 5,693 and the total injured 27,898. These are the returns made by the railroad companies themselves, and they cannot well be suspected of exaggeration. Neither is there, on the other hand, any reason to suppose that they are not, in most cases, complete and prepared with perfect good faith.

A thought strikingly suggested by these figures is that accidents to passengers take up an undue proportion of the public attention. Not only are casualties to employés several times more numerous, but they are concentrated upon a comparatively small class, each individual of which undergoes considerable hazard. Some estimate of how great this hazard is in the case of one class of employés may be made from the records of the Brotherhood of Railroad Brakemen, an organization that has for one of its objects the insurance of its members against death or total disability. During the year 1888 the average membership of this Brotherhood was 10,052.5. Insurance has been paid upon 114 deaths and 53 total disabilities, the result of injuries received from railroad cars during that year. In the same time there were only 31 deaths and 6 total disabilities from natural causes. These data are taken from the printed assessment notices of the order. Thus one in every 88 of the members of this organization is killed yearly, and one in 60 suffers either death or total disability. It appears also that a brakeman has only 31 chances in 145, or 1 in 4.7, of being allowed to die a natural death.

Exception may, perhaps, be taken to this conclusion on the ground that brakemen are mostly young and vigorous men not likely to die from natural causes, but surely this view of the case is not more satisfactory than the other. No record is kept showing the number of lesser injuries received, but if the ratio of killed to wounded is taken as the same as that which, according to the figures quoted above, holds good in accidents to railroad employés over the country at large, namely, 1 to 9.73, the number of those receiving injuries serious enough to be reported to the Commission would be, exclusive of the killed, 1,109, or 1 in 9 of the members of the order. It would appear from this result that, besides running great danger of death, a brakeman will, on the average, be injured once for every nine years of service. It should be said that this Brotherhood includes quite a number of conductors and others whose occupation is less dangerous than that of brakemen, so that the hazard to brakemen is presumably somewhat greater than here shown. It is probable that no occupation followed in this country by any large class surpasses in danger that of the railroad brakemen.

It having been urged upon the Commission from several quarters, but more particularly by the State Railroad Commissioners at the Convention in March, that there was a necessity for some sort of national action in matters relating to safety on railroads, an investigation of the subject was begun in the spring of the present year. Although information has been obtained principally from miscellaneous sources, two circulars have been issued making inquiry concerning matters of special importance. The first, dated April 1, dealt especially with automatic freight-car couplers, and called not only for facts but for technical opinion. It was addressed to the heads of the car-building departments of all the leading roads. The second, issued May 17, concerned the general subject of Federal regulation of the mechanical features of railroad working, and was intended to call out from those best informed and most interested the fullest discussion of that subject and of the facts bearing upon it. It was addressed to all State Railroad Commissioners, to the Grand Masters of the chief organizations of railroad employés, and to a number of railroad experts and others who were known to have made special study of the matters in question. A number of the replies to this circular were prepared with much care and have great value, being, in fact, thoughtful discussions of the matters suggested by the circular, written from various points of view by men of ability and special knowledge.

The question of the prevention of loss of life and limb on railroads has received study of late years from various quarters. It has been carefully investigated by the various State commissions whose reports have served as a guide to legislatures, to public sentiment, and often to the railroads themselves. In no direction has inventive and executive mechanical genius been more active or, on the whole, more successful. Some of the American inventors are not unworthy to be classed with Stephenson himself for what they have done to aid and perfect railroad transportation. But perhaps the most important work of all, as far as mechanical appliances are concerned, has been done by the Master Car-Builders' Association, an organization little known to the general public, developed by the railroad corporations themselves to meet certain requirements of modern railroading. This Association meets annually, and, as regards one of its most important purposes, may be not inappropriately described as a federal assembly of car-shops, in which each railroad corporation has a voice, proportioned to the number of cars it owns, in determining upon those standards of uniform construction which extensive interchange of cars makes necessary. The conclusions of this body are recommendatory and not binding upon its members, its careful methods of procedure, likely to assure the best results, and the economies dependent upon uniform construction being relied upon to support its recommendations. Any improvement in safety appliances, then, which depends for its success upon uni-

form action by railroads all over the country, and the most important do so depend, must first secure the approval of the Master Car-Builders' Association.

The importance of this Association will further appear in the course of a brief sketch of some of the problems relating to public safety which apparently call for solution through national legislation.

(This is followed by a condensed account of the action so far taken by the Association on Automatic Couplers, on Freight Train Brakes, and on Car Heaters, and of the legislation on the same subjects in different States. Opinions of several of the State commissions are also given.)

PROBLEM OF FEDERAL REGULATION.

If it is assumed that the condition of things thus briefly outlined calls for some Federal action in the interest of safety, particularly of the safety of workmen in railroad employ, it remains to consider what that action should be.

Two distinct ways of proceeding are naturally suggested. Congress may, should it see fit, pass definite statutes requiring that certain appliances be brought into use upon all the railroads of the country within a certain time; or, having in view the difficulty and importance of the question, it may prefer to make some provision for its further investigation, trusting that the mere fact that such an investigation is in progress will not be without immediate results.

This Commission is not prepared to recommend a national law prescribing appliances. It does not assume to say that such legislation will never be advisable, but it is not prepared to say that it is advisable at present. The difficulties of formulating a law from which good results could be expected are certainly very great, if not insurmountable, and, although pains have been taken to secure the views of all interested, no legislation of this sort has been suggested that seems plainly to be wise and safe. A statute requiring that all freight cars be fitted with automatic couplers by a certain date—a requirement against which it is probable that less could be urged than against any others suggested—has already been shown to be open to serious objections. It is impossible to say what the results of such a law would be, but there is no certainty that they would be good. If it did not bring about uniformity—and there is no assurance that it would—it would be most injurious to all interests involved, including those of public safety.

While it is no doubt highly desirable that results be reached as soon as possible, it is still more desirable that no mistakes be made. Nothing could be more unfortunate than a repetition, on an enormous scale, of the unsatisfactory results of State legislation. If the State statutes of a few years ago regarding couplers had been national statutes, it seems plain that the question would be in less hopeful condition than it is at present. The effect of that legislation was to hasten the adoption of a variety of automatic couplers, most of which must, of course, be set aside if uniformity is to be attained. In fact, the strongest opposition to the Master Car-Builders' type of coupler—the one that, so far as can be seen, has most chance of uniform adoption—is found in New England, where, as a result of State legislation, automatic couplers not of that type have secured a strong hold. A reasonable prudence and regard for the lessons of previous experience require that action involving the compulsory use of particular appliances should be undertaken only with the greatest caution and upon more thorough investigation than has as yet been practicable. It has been suggested that for the present, at least, the interests of safety would be better served by providing for a board of specialists, so constituted as to command respect from both the railroads and the public, whose business it would be to make investigations and recommendations relating to railroad casualties.

To determine in detail precisely how such a board or bureau should be organized, just how much it should be expected to accomplish, and what powers should be given it, is a matter of much delicacy, in the study of which careful attention should be given to bodies of a similar sort now in existence.

Although we have had in this country no national inspection of railways, we have had for nearly 50 years something closely analogous to it in the steam-boat inspection service. And to find a nation which undertakes the inspection of railways with a view to the protection of human life we need go no farther than England, a country where the relations between railways and the Government are in many respects similar to what we have at home. Such inspection is also undertaken in the countries of the Continent of Europe, but as the conditions in those countries are much less like our own than those in England, their methods are not so instructive. These two examples of effort on the part of Government to increase the security of human life, the steam-boat inspection service of the United States and the English system of railway inspection, may profitably be regarded as representative of two distinct principles, both of which may be usefully studied in dealing with the subject now under consideration. In the former we have an example of an inspecting agency which not only investigates safety appliances and makes recommendations and reports, but also has considerable powers of actual interference and control. In the English statute under which inspectors are appointed it is expressly provided that "no person so appointed shall exercise any powers of interference in the affairs of any company." Both systems are successful, but it is clear that this success must be achieved in somewhat different manners. It is clear also that the inspecting agency, which has the more power, will require the more elaborate organization and incur the greater responsibilities. The system of steam-boat inspection under our own laws is assumed to be familiar; a brief statement of the system of railway inspection in England is here given.

Although the English system of inspection of railroads by officers acting under the direction of the Board of Trade dates back to 1840, the statute determining the powers and duties of the present inspectors was passed, like our act to regulate steam-vessels, in 1871. That statute, after authorizing the appointment of inspectors, "provided that no person so appointed shall exercise any powers of interference in the affairs of any company," gives each inspector power to inspect any railroad, and all its stations, works, buildings, rolling stock, etc.; to require the attendance before him of any person in the management or employ of a company; to require such person to answer his inquiries, and to enforce the production of any papers he considers important for his purpose. Provision is also made for a more formal investigation in very serious cases to be conducted by a court, consisting of an inspector and persons designated by the Board of Trade to assist him. Such a court has no power beyond what is necessary for investigation. Its function ends when it submits a report of its findings to the Board of Trade.

Under this act the Board of Trade appoints as inspectors three officers detailed from the Royal Engineers.

Their position is practically a permanent one, and they are, of course, men whose character and abilities command respect from all quarters. Whenever an accident occurs in the United Kingdom of which the Board of Trade desire to make investigation (there need not necessarily have been any loss of life) one of these officers is selected to make it. He proceeds to the scene of the accident, conducts his investigation, and makes his report. As soon as this is printed a copy is sent to the management of the company on whose line the accident occurred. A blue book containing these special reports, together with complete accident statistics, is published quarterly. The number of reports for each quarter, of course, varies greatly, but the average is about 25. They enter into minute detail and yet are clear and vigorous. A short account of the accident and the damage done in it comes first; then follows a careful description of the surroundings; then the evidence in a concise form; and finally the concluding portion, in which the accident is discussed, responsibility fixed, and recommendations made.

The only power in the nature of actual interference which inspecting officers exercise is in the case of a new line. Such a line cannot be opened till the Board of Trade gives its sanction, and the inspecting officers can and do require that everything that they think necessary for safety be provided before they recommend that this sanction be given. But when sanction is once given, the Board has

no further power. After the line is open the company may even remove works which it has erected to obtain the Board's sanction ; and there is no remedy.

Besides the quarterly publication of returns of accidents already mentioned, two other documents, relating to safety appliances, are regularly issued by the Board of Trade. One is issued half-yearly, and relates to continuous brakes on passenger trains. It is made up chiefly of returns which the companies are by act of Parliament required to make, showing in the most complete manner the number and proportion of passenger cars fitted with continuous brakes, the kind of brakes used, every case of failure of continuous brakes to act, giving cause of failure in detail, and in general the progress in the use of continuous brakes from year to year. The second document is published yearly and contains similar returns relative to the interlocking of switch and signal levers and the block system. The purpose of these publications seems to be to assure complete publicity, to keep the people and the railroads themselves alive to what the latter are or are not doing, and at the same time to furnish data from which the efficiency of various appliances may be studied. In addition to these regular publications the Board from time to time issues circulars pertaining to matters in which especial pressure seems to be necessary.

Although the success of this unpretentious system of regulation has been very decided, there has frequently, at times when accidents appeared especially numerous, been considerable agitation to have the supervisory authority of the Board of Trade extended. After investigation, however, the proposition to give the Board powers of direct control has invariably been rejected, and none have opposed it more strongly than the Board itself and its inspecting officers. During the past 30 years the prevention of accidents has several times been the subject of parliamentary inquiries, the most thorough of which was made by a royal commission appointed in 1874. Their report, presented three years later, is accompanied by a quarto volume of evidence, containing 1,150 pages.

Regarding an extension of the powers of the Board of Trade, they speak as follows : . . . "Upon full consideration we are not prepared to recommend any legislation authorizing such an interference with railways as would impair in any way the responsibility of the companies for injury or loss of life caused by accident on their lines. To impose on any public department the duty and to intrust it with the necessary powers to exercise a general control over the practical administration of railways would not, in our opinion, be either prudent or desirable. A Government authority placed in such a position would be exposed to the danger either of appearing indirectly to guarantee works, appliances, and arrangements which might practically prove faulty or insufficient, or else of interfering with railway management to an extent which would soon alienate from it public sympathy and confidence, and thus destroy its moral influence, and with it its capacity for usefulness."

This reasoning seems to be amply supported by the evidence, and, together with the objections noticed in considering the steam-boat inspection service, is believed to be conclusive against the institution of an administrative agency with power to enforce upon railroads the use of particular appliances.

In the consideration of the general subject of railroad inspection and supervision it should not be overlooked that there are in many of the States, if not all, statutory provisions of more or less vigor for the inspection of railroads in the respective States by State officials. The reports of some of the State railroad commissions show that their inspection of the railroad as a structure is very thorough. Some of the reports are also very full and complete as to accidents, showing their cause, nature, and extent, and in establishing the individual responsibility therefor when negligence or want of care was the cause. Twenty-six States have already provided for State commissions, with powers and duties varying somewhat in degree, but of the same general character. The tendency is in the direction of increased power and duties in these boards. Judging from their rapid growth in the past both in numbers and scope, probably every State will soon have a commission upon which will be imposed, among other things, the duty of thorough annual inspection of the roads in each State, respectively, and of investigation of all matters pertaining to accidents and injuries in railroad operations. The necessity for Federal inspection and regulation will exist, as already shown, more especially where uniformity is required in safety appliances in the train equipment.

With these general statements the whole subject is submitted to the wisdom of Congress. It will be perfectly obvious, on what is stated, that if any system of Federal inspection or supervision in respect to railroad appliances is provided for, it must be impossible for the members of this Commission in person to perform the duties of such inspection and supervision.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

III. LARD OIL.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page* 35.)

Not the least among the changes produced by the development of the petroleum industry, during the last 25 or 30 years, is the diminution in the use by railroads, of what may be called in general, fatty oils. Thirty years ago, both sperm and whale oils were largely used both for burning and lubrication ; candles made from tallow were also largely used as a source of light. *Lard oil* in its various grades was also used both for lubrication and burning, but the constant diminution in the prices of the petroleum products, together with the constant approximation in usefulness of these same products, produced by improved methods of refining, have almost completely wiped out the use of both sperm oil and whale oil for burning and lubrication, and have, to an enormous extent, diminished the use of lard, neat's-foot, mustard-seed, and other animal and vegetable oils of the same nature, for these purposes. Great as the inroads of petroleum products have been, however, they have not yet succeeded in completely doing away with the use of fatty oils for railroad purposes. For certain uses both in burning and lubrication, a percentage of some fatty oil is still apparently a requisite. No petroleum product has yet been devised which meets all the requirements for an oil to be burned in hand-lanterns, and no petroleum product, so far as we are aware, has yet come forward, which fills all the requirements of a lubricant with perfect satisfaction. Railroads are therefore still continuing to use, although in constantly diminishing quantity, some of the fatty oils both for burning and lubrication. In this country lard oil is used most largely for these purposes ; mustard-seed oil and colza oil are also used as constituents of burning oils, and neat's-foot and tallow oils, to a limited extent, as constituents of lubricating oils. In the North of Europe, colza oil is almost entirely the fatty oil constituent of both lubri-

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* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I., in the Journal for December, is on the Work of the Chemist on a Railroad ; No. II., in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these Contributions to Practical Railroad Information of special value in indicating the true character of the materials they must use and buy.

cating and burning oils, while in Spain and Italy, olive oil is largely used in the same way.

The uses of railroad companies are principally confined to two grades of lard oil, the one known in the market as extra lard oil, or prime lard oil ; the second, known under various names as extra No. 1, or No. 1. The first, which is the better grade, is used largely for burning ; the second, or poorer and cheaper grade, is used principally for lubrication. Neither of them, so far as we know at present, however, are used unmixed with other oils, for either of these purposes. The uses of these oils in detail will be given in a subsequent article, the present article being confined more especially to the sources, method of manufacture, adulterants, and tests of these oils.

Lard oil, as the name indicates, is made from lard, lard being, as is well known, the fat of the hog. This fat is obtained from the fat tissues in much the same way that tallow is obtained from the fat tissues of the beef, namely, by heat, which causes the enclosing tissues to shrivel and release the fat, the last portions of the fat being removed from the "cracklings" by pressure the same as with tallow. If the hogs are healthy and are freshly slaughtered, the resulting product is known in the market as prime lard, and the material is sufficiently good to be used for culinary purposes. If the animals are not healthy, or if, as frequently happens, the animals during transportation on cars from the feeding place, to the slaughtering establishments, die by becoming smothered, or by being injured in any other way, not only the specially characteristic fat tissues, the same as with healthy freshly-slaughtered hogs, but also all the fat tissues of the animal, are "rendered"—that is, all the fat that is in the animal is taken out as lard, since the animal is worthless for food. Strictly speaking, the fat obtained from animals of this nature is not called lard, its proper name in the market being "grease ;" it is also sometimes called "dead hog stock." There are many varieties of grease, some of them so white and clean that no one but an expert would distinguish them from the prime lard. The grading goes down in the scale to greases which are very offensive in odor, and many of them very dark in color, depending on the length of time that the animal has been dead before the fat is rendered.

Extra or prime lard oil should always be made from prime lard—that is, the very best quality of lard that can be obtained. It is to be feared that many times, more or less, No. 1 white grease is used even in making the better grade of lard oil. The extra No. 1, or No. 1 lard oil is made from various mixtures of different grades of grease, and some of the poorer greases are used also in making a grade of oil known as No. 2 lard oil. Very little of this oil, as we understand the matter, is used by railroad companies. As will be readily understood, the prime lard is the most expensive in the market, the No. 1 white grease next, and so on through the different gradings, each lower grade being less expensive. The natural tendency of the manufacturers would be to use as much of the less expensive material as possible in making the better grades of oil.

Speaking chemically, lard is principally a mixture of stearin and olein, which chemical bodies were described in the last article of this series, on Tallow. Stearin is a solid at ordinary temperatures, its melting-point being above 120° Fahrenheit, while olein is a liquid at ordinary temperatures, pure olein remaining liquid, even at a temperature below 50° Fahrenheit. The proportions of stearin and olein in lard are not far from 60 per cent. olein and 40 per cent. stearin. These percentages vary somewhat with the food of the animal, and also, apparently, the chemical composition of the fat of the hog is influenced by the food of the animal.

A very interesting illustration of this peculiarity occurred in our experience a few years ago. Fifty tierces of lard were purchased to be used in making lard oil. On examination this lard had a very low melting-point, and treated chemically did not behave as pure lard made from corn-fed hogs does. It was thought, although not definitely proven, that the lard had been mixed with cotton-seed oil as an adulterant. The information going to the parties, they were somewhat indignant, and refused to receive the lard back, saying that it was perfectly pure hog fat. As the result of further correspondence, they came to Altoona and talked the matter over, and explained that the lard in question was obtained from what are known as mast-fed hogs—that is, hogs that run at large quite a portion of the year in the woods, eating in the autumn large quantities of nuts and other food of this nature, which they could pick up. The shipment in question came from Kentucky. It is doubtless well known that it is customary to harden up the fat of the animal in most places with corn before slaughtering. The parties who furnished the lard in dispute claimed that it was well known in the trade, that lard from mast-fed hogs and also from distillery-fed hogs, had a much lower melting-point and was more oily than that from corn-fed hogs. On looking up the literature of the case, very little was found, and in view of the doubt, and the well-known and unquestioned integrity of the parties furnishing the lard, the shipment was accepted.

The statements in the books, so far as definite statements were made, were practically to the effect that very little was known on the subject of whether the nature of the food influenced the fat secretion, but the general belief among physiological chemists was that it did not. Subsequent correspondence with the professors of physiological chemistry in several of the colleges of the country developed little additional. The question was so interesting, however, that arrangements were made with the parties who furnished this shipment of lard to send to us at Altoona some of the fat taken from a mast-fed hog and for comparison some taken from a corn-fed hog. This was subsequently done and the lard from these two kinds of fat was rendered in the laboratory. On examining the product the same characteristics that had been previously found manifested themselves, namely, the lard from the corn-fed hog corresponded entirely in melting-point and chemical behavior to the usual tests. The fat from the mast-fed hog was, as in the case of the shipment above described, much lower in melting-point, and did not behave under the same tests in the same manner as the lard from the corn-fed hog. So far as this single experiment goes, therefore, the indications seem to be that the food does influence to quite an extent the fat secretion. Samples of these two lards were subsequently sent to one of the technical schools, with the hope that further study would be put on the subject, but no definite conclusions were ever reached. It seems probable that much light might be thrown on the nature of the fat secretion by following out the line here indicated.

It is not difficult to understand that lard oil is simply the oily part of the lard, the olein, the 60 per cent., as above described. In making lard oil, therefore, the problem is, how to separate the olein from the stearin. For this purpose advantage is taken of the different melting-points of the two substances. In the best practice the lard is placed in cellars, usually underneath the ice-house, where the temperature is maintained at about 50° Fahrenheit. As soon as it has become cooled down to this temperature the lard is taken out of the tierces, and put in strong cloths, in packages 12 or 15 in. square, containing about 20 or 25 lbs. in each cloth. These packages of lard in the cloths, are then placed one above another, with a board between, a pile 8 ft. or 10 ft. high being made. A board is placed over the top package and then the whole pile is subjected to pressure. The oily part of the lard, the olein, being liquid at the temperature maintained, is gradually squeezed out by the pressure, runs down over the boards into a conduit at the bottom, and is then conveyed away to storage tanks. The stearin being solid at this temperature, remains behind in the cloths. Gradually, as the oil runs out, the pile settles, and the pressure is maintained either automatically or by screws. Of course this separation being a mechanical one, it is not believed that all the stearin is left behind, nor that all of that which runs out is olein, but the separation is sufficiently good for practical and commercial purposes. The efficiency of the separation is very largely a function of the temperature. If the temperature of the room where the pressing is done is 70° Fahrenheit, larger portions of the stearin go into the oil. The older practice recognizes summer and winter oil, the summer oil being made in the summer, and the winter oil in the winter, as the names indicate. This was before the artificial means of keeping the temperature of the room down

to about 50° Fahrenheit had been made use of, and the oil-makers had to press the oil at whatever temperature the location of the presses and the season of the year gave them. As stated above, however, the best practice now cools the rooms where the pressing is done to a uniform temperature of about 50° Fahrenheit, and it is possible to obtain throughout the year what is known in the market as "winter-strained oil." So far as our observation goes no difficulties arise in the summer season in using summer-strained oil, but an attempt to use summer oil in the winter season may cause difficulty on account of the summer oil congealing at a considerably higher temperature than the winter oil. The stearin which is left behind in the cloths is known in the market as "prime stearin," provided prime lard is used, and is used legitimately and principally to mix with other prime lard, and thus make family lard, which goes to warmer climates, the object of the mixture of stearin with ordinary lard being to raise the melting-point and cause the lard to keep better in the warmer countries. The extra No. 1, the No. 1, and the No. 2 lard oils are made in exactly the same way as has just been described, the difference being the quality of the material from which the oil is made—No. 1 and possibly No. 2 grease mixed making extra No. 1 lard oil, a little poorer grade making No. 1 lard oil, and a still poorer grade making No. 2 lard oil. The stearin from the manufacture of these lower grades of lard oil is legitimately and principally used for soap-making.

The characteristics of the two grades of lard oil in common use on railroads, by which they may be distinguished from each other, are simple. The prime or extra lard oil is slightly olive-green in color, flows at ordinary temperatures slowly, compared with water, has a moderately viscous oily feeling when rubbed between the finger and the palm of the hand, and has a rather characteristic pleasant, sweet odor. The extra No. 1 lard oil of best grade is a very dark amber, or yellowish red, or reddish yellow, or, more accurately, it is the color produced by mixing small amounts of red with large amounts of light olive-green; the No. 1 lard oil is darker red, and the No. 2 lard oil still darker red. The extra No. 1 lard oil flows a little more readily than the prime or extra lard oil, has not quite so viscous a feeling under the finger, and is characterized by a somewhat offensive odor; the No. 1 lard oil is still more offensive, and the No. 2 can hardly be used as a lubricant for oiling machinery or shafting on account of the very offensive odor to the workmen.

The principal chemical distinction between the prime and other grades of lard oil is in the amount of free fatty acid which they contain. As in the case of tallow decomposition sets in as soon, apparently, as the animal is dead, and after two or three days have elapsed, between the death of the animal and the rendering of the lard, quite large amounts of free acid have already been formed. The best quality of prime or extra lard oil should not contain over 0.50 per cent. of free acid. It might be called, however, prime or extra lard oil until the amount of free acid reaches 2.00 per cent. The amount of free acid in the extra No. 1, No. 1, and No. 2 lard oils is variable. In the Pennsylvania Railroad specifications, lard oil is recognized as extra No. 1 until the amount reaches 15.00 per cent. We are not aware that any limits of free acid have been agreed upon commercially, by the different boards of trade, as to the distinctions between extra No. 1, No. 1, and No. 2 lard oils. Formerly the grading of this oil was wholly on color, and this grading still prevails to quite an extent, the odor likewise being used as an element in deciding the quality. This use of color and odor as a means of grading, we regard as entirely legitimate. The color, as we understand it, is due to the oxidation of the free oleic acid in the oil, and the odor is due to the state of decomposition of the animal before the fat is rendered, or possibly to the decomposition of the fat after it has been freed from the tissue. The longer the animal has been dead before the fat is rendered, and the greater the exposure of the grease to the light and air before the oil is made, the darker the color of the oil and the worse the odor. Both these characteristics, therefore, indicate a product that has not been as properly cared for, and has, therefore, not cost as much to produce as oil of better color and odor, and consequently could not fairly claim to be regarded as worth as much as a product having less color and less odor. The difference in price between the extra or prime and the extra No. 1, varies from 3 cents to 12 or 15 cents per gall., apparently depending on the relative supply of the materials from which the two oils are made.

The usual adulterants or falsifications of lard oil are (1) admixture of other oils with it, and (2) attempts to sell the inferior grade for the better grade. Lard oil, especially the extra or prime grade, being the most expensive oil used by railroads, the tendency to mix cheaper grades of oil with it is very great. This tendency was much greater 12 or 14 years ago than it is now. At that time lard oil of the best grade was worth $1 to $1.10 per gall., cotton-seed oil was worth 50 to 55 cents per gall., and the petroleum product which could be used to mix with lard oil was worth 20 to 30 cents per gall. In our experience, embracing now something over 14 years, we have found very little attempt to mix petroleum products with lard oils. This may be due to the fact that very early in the history of the Pennsylvania Railroad Laboratory the testing of lard oil was taken up, and the manufacturers soon became conscious that their product was being pretty carefully examined. There is very little doubt, we think, but that petroleum products are mixed in the market with lard oil, but very little of this material has been offered to the Pennsylvania Railroad Company during the past 13 years.

The attempts to sell inferior grades under the name of a better one will be discussed when we come to the question of tests.

The most dangerous and at the same time the most common adulterant of lard oil is cotton-seed oil, and our experience with this material has been quite an interesting one. The difference in price some 12 or 13 years ago, as stated above, produced a very strong tendency to mix the two oils, and under the pressure produced by competition the manufacturers did not seem to be able to resist the tendency. The importance of this tendency to mix cotton-seed oil with lard oils was not limited to the fact that railroad companies were buying cotton-seed oil, which could be obtained in the market at 55 cents per gall. mixed with lard oil, and paying $1 to $1.10 per gall. for the mixture, but the effects on the service were still more disastrous. This point we will try to make clear.

As has already been stated the prime lard oil is used principally as a constituent of burning oil, the mixed oil made by its use being known in railroad language as "signal oil." This oil is used in the hand-lanterns everywhere, and also for rear-end signals on trains, in switch lamps and other places where signals are maintained. Cotton-seed oil, being what is known technically as a "semi-drying oil," that is, an oil that absorbs oxygen and becomes gummy or resinous thereby, does not burn well. Repeated experiments using cotton-seed oil in place of lard oil, in making signal oil, show that when the wick is new, and the lamp first trimmed, it will burn about eight hours before going out, the second time a little over seven hours, and then the time diminishes to about six hours each time before the lamp goes out of itself. The going out of the lamp is caused by the formation of a crust, which begins at the top of the lamp-tube, when the lamp is burning, and creeps up until it finally covers the whole top of the wick, and prevents further flow of the oil. This crust is apparently an oxidized product of the cotton-seed oil—a semi-resin. The same phenomena occurs in less degree when lard oil, which has been mixed with cotton-seed oil, is used in making signal oil. The same resinous crust forms and ultimately extinguishes the light, the only difference being that the lamp will burn longer before going out. In view of the fact that in the darkest weather signals must burn 14 hours without attention, and in view of the fact that not only the safety of trains, but also the operation of the road with success at all, depends on the maintenance of the signals, the importance of the subject can be inferred.

It is, of course, a legitimate query whether a small percentage of cotton-seed oil might not be used in making signal oil, and this question was made the subject of careful experimentation. The results indicated that possibly 10 per cent. of cotton-seed oil might be used, but in view of the tremendous issues which hang on signals, no at-

tempt was ever made to utilize this information. The losses resulting from a single failure of signals might 10 times over counterbalance any saving effected ; indeed, it has almost passed into a proverb among those controlling such matters on the Pennsylvania Railroad, that no railroad can afford to take any risks in regard to the quality of its signal oil.

The extra No. 1 lard oil, when mixed with cotton-seed oil and used for lubrication, always likewise gives very bad results in service. As has already been explained, the cotton-seed oil being a semi-drying oil, the lubricating oil made by its use is in every sense inferior on account of the rapid "gumming."

At the time referred to above, some 12 to 14 years ago, the extra No. 1 grade was worth from 70 to 80 cents per gall., and the No. 1 possibly from 5 to 10 cents less, and the No. 2 about 15 to 20 cents less. The difference in price between these oils and cotton-seed not being as great, therefore, it would be expected that the disposition to adulterate or mix them would not be as great. But cotton-seed oil being a bright, clean oil, free from odor and color, it was soon found by the manufacturers or dealers that a poor grade of No. 1 or even a No. 2 lard oil might be brought up in appearance to the extra No. 1 grade by adding to it enough cotton-seed oil. We have seen samples of so-called extra No. 1 lard oil, which were only one-half lard oil and which by color and odor would fairly be called extra No. 1. A little calculation will readily show that mixing cotton-seed oil worth 55 cents a gall. with No. 2 lard oil, worth also 55 cents, and selling the resulting mixture at 75 cents a gallon, would afford a nice margin over any probable cost of the labor of mixing.

In view of this state of affairs the question of the purity of the lard oil was made a subject of special study within a year after the laboratory was started. At that time cotton-seed oil was so new, and so little chemical work had been done on it, that almost nothing could be obtained from the literature of the subject to help in detecting its admixture with lard oil. Most of the commercial chemists declared themselves incapable of telling whether a sample of lard oil was adulterated with cotton-seed oil or not, and the general feeling among chemists was that, in the present state of knowledge, it was impossible to do so. In view of this state of affairs rather vigorous study was applied to the question, and more, perhaps, by good fortune than skill, a test was devised which enabled the Pennsylvania Railroad Laboratory to say whether or not a sample of lard oil submitted to it was made from the lard of corn-fed hogs. The test did not decide whether the admixture, if any, was cotton-seed oil or some other kind of oil, and although on test, samples where the proportions of the other oils mixed with the lard oil were known, results could be obtained within a fraction of one per cent., no attempts were ever made to reject oil shipments that contained less than 5.00 per cent. of some other oil.

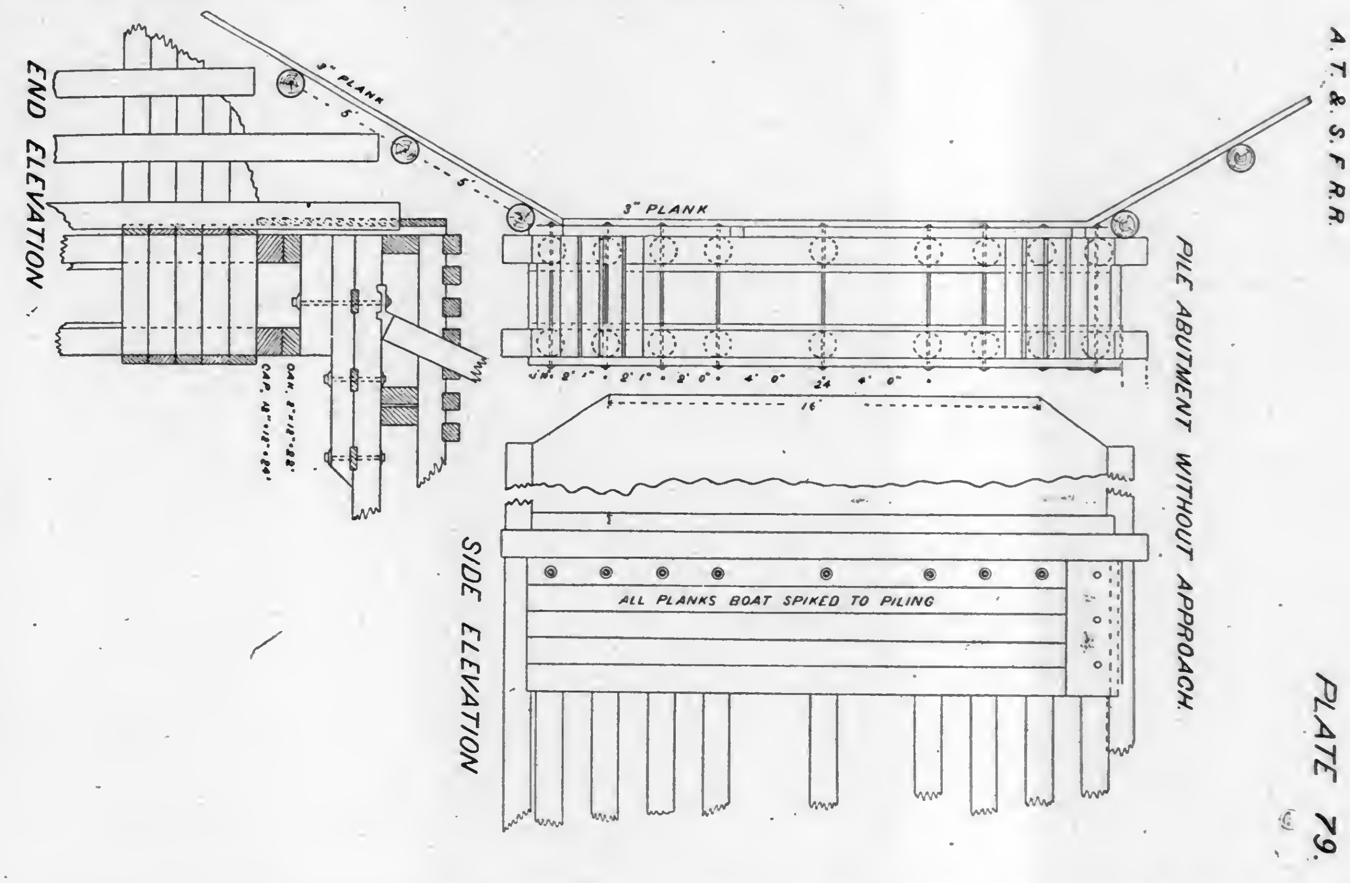
After this test was devised the question arose as to utilizing it, and the Purchasing Department said, with much good sense, that they hardly felt like charging men engaged in business with adulteration or falsification, and accordingly they proposed that the laboratory should be furnished by the manufacturers toward the end of each month with samples of such lard oils as they were willing to furnish for the next month's supplies. These samples being tested, if any of them showed lack of purity, no order would be placed with the parties furnishing this sample. If the sample was all right and an order placed, and the subsequent shipment showed lack of purity, it would be sufficient to the manufacturer to say that the oil was not like the sample. No question of purity or adulteration or falsification was raised, and if the matter went so far as to require a demonstration in the presence of a referee or unbiassed parties, it would certainly be only found necessary to repeat the test of the sample on which the purchase was made and the sample from shipment in the presence of the parties. This method was adopted, and has worked so well, that it has really been in constant force on the Pennsylvania Railroad for some 12 years, and has undoubtedly saved many disputes.

The test and the method of buying having been decided on, the monthly samples on which to make purchases were sent. The first month 13 samples were sent. Some of these samples represented extra or prime lard oil and some extra No. 1 lard oil. Some six or seven different manufacturing firms were represented by the samples. The examination showed that only three of the samples were pure, corn-fed lard oils. The following month 17 samples were sent, and in this case seven samples were pure. In the course of six months it was rare to receive a sample that was not pure lard oil, and in the course of a year or two the contests with the manufacturers over the purity of the different grades of lard oil had pretty nearly all disappeared, and it has been a long time now since either a monthly sample or a shipment of lard oil containing any adulteration or admixture has been offered to the Pennsylvania Railroad.

A single illustration of an actual occurrence during the time of contest for purity of lard oil may be of interest. Soon after the method of buying, above described, had been established, an order was placed with a large firm for 5,000 galls. of prime lard oil, the price being $1.05 per gall. On receiving the shipment a sample was tested and was found to contain 25 per cent. of oil that was not lard oil. This information was sent to the Purchasing Department, who wrote the parties that the oil was not like the sample on which the purchase was made, and if the adulteration was cotton-seed oil there was about 25 per cent. of it ; also requesting the parties to take away the shipment and replace it with pure oil. The parties were very indignant and wrote a somewhat impudent letter, to the effect that the oil was pure lard oil, that their business standing was such that their oil ought not to be subjected to tests, that they regarded it as an imposition on their honesty, and that they would not receive the oil back again. A little firmness on the part of the Purchasing Agent resulted in their sending for the oil. One week after that they wrote a letter stating that they would be glad to send another 100 barrels in place of the 100 barrels rejected. The Purchasing Agent replied that they might send the material, subject to test at Altoona. If the oil passed test, the company would take the oil and be glad of it ; if not they must take it back again. The shipment was made under these conditions, and on examination proved to be as fine a grade of extra lard oil as it has ever been our fortune to test. The commercial side of this case is interesting. The bill for this oil was $5,050 ; our subsequent experience makes us feel certain that the adulterant used in this case was cotton-seed oil, which at that time was 55 cents per gall. The shipment by our test, therefore, contained 1,250 galls. of oil having a market rate of 55 cents per gall., and 3,750 galls. of oil having a market rate of $1.05. Each gall. of the adulterant, therefore, afforded a clear profit of 50 cents, or the net fraud on the purchaser in this transaction was $625.00.

Since those early days of contest over cotton-seed oil, the relative prices of lard oil and cotton-seed oil have approximated each other, until now there is not much difference, and therefore there is not as much temptation to mix cotton-seed oil with lard oil. It is impossible, of course, for us to say what oils are offered those companies who have no laboratories and who do not have their supplies tested in any way. We have occasionally been appealed to by officers of other railroads to decide questions in regard to shipments, and have found in almost every case that the disposition to mix cheaper with better oils has not entirely ceased.

In addition to the petroleum products and cotton-seed oil, which are the most common adulterants, it is not impossible that any one of the following oils may be found in the market mixed with lard oils, viz. : Resin oil, peanut oil, corn oil, fish oils, especially menhaden, black fish, sea elephant, and the cheaper porpoise and whale oils, also the cheaper grades of olive oil, neat's-foot oil, tallow oil, colza oil, and mustard-seed oil. Nearly all of these oils have been brought to our attention and have been studied more or less during the past 14 years. Most of them, except resin oil, are so near the price of the lard oils, or their admixture with the lard oils is so easily detected, that serious adulteration by means of them is at present improbable. A change in the abundance of the supply of any of them, causing a marked drop in price, or improved methods of



treating many of these oils, making their detection in mixtures less easy, may, however, occur at any time, and there is therefore no safety except a test of every shipment and constant watchfulness on the part of an able chemist.

In the next article of this series we will consider the specifications for Lard Oils, now in force on the Pennsylvania Railroad, and the methods of testing adopted.

(TO BE CONTINUED.)

THE USE OF WOOD IN RAILROAD STRUCTURES.

By CHARLES DAVIS JAMESON, C.E.

(*Continued from page* 29.)

CHAPTER XX.

PILE ABUTMENTS AND PIERS.

BEFORE taking up the subject of Wooden Bridges in all its details, we wish to call attention to a class of structures upon which for many years these wooden bridges rested—that is, Pile and Timber Abutments and Piers.

All the earlier bridges rested upon either piles or cribwork filled with stone, and it is only within a few years that stone foundations have been carried to any depth below the water.

Upon new roads and in thinly inhabited countries, where wood is easily obtained of a good quality, this same method of supporting short-span bridges can be and is still used with an economical result.

Such structures are open to the two great objections inherent in the use of wood, and these are—Fire and Decay. In this case, however, the inevitable decay is the more important, as under ordinary circumstances the danger from fire is very slight.

Plates 79, 80, and 81 show the standard plans of these structures as used upon the Atchison, Topeka & Santa Fé Railroad.

Up to a height of 30 ft. above the ground the piles themselves may be used as a framework for the structure, but above this height, or even 5 ft. to 10 ft. below it, it is often more secure and more economical to cut the piles off some 2 ft. or 3 ft. above the ground and to secure a good foundation by drift-bolting caps to them; then upon the caps building a special frame with plumb-posts, batter-posts, etc., upon the same principles that have been laid down for framed bents, etc.

In all of these structures especial attention must be paid to the thorough spiking or bolting of every piece to its place. Whether the piles themselves are used as a frame, or a special frame is built resting upon the piles, the outside of this frame should be carefully planked with 4 in. oak plank to a point above high-water line and above the ice-line. The plank should be boat-spiked to each pile.

When the piles are used as a frame, there should be a timber about 8 in. × 10 in. run around upon the inside, near the top of the piles, and bolted to each pile by a bolt not less than ¾ in. in diameter. When the piles extend anywhere near 30 ft. above the ground there should be several of these stiffening timbers used, spaced at proper intervals between the ground and the top of the piles.

As will be seen by an examination of the plates, there are usually two rows of piles. Upon the top of these piles, and running at right angles to the line of track, are bolted double caps, the top one being 8 in. × 12 in. in size and of oak. Upon these caps rest the blocks, bolsters, etc., which support the bridge proper.

Plate 79 shows plans of a pile abutment without approaches. This plan should never be used excepting under circumstances which make it impossible to use the plan shown in Plate 80. Always, when it is not absolutely impossible, pile or trestle approaches should be used to all wooden abutments.

Plate 81 shows a plan of a pile pier. In this, as in the abutment, the piles can be carried up to serve as a frame, or they may be cut off and serve only as a foundation to a special frame. The main part of the pier consists of four rows of piles, spaced 2 ft. 8 in. from center to center, the

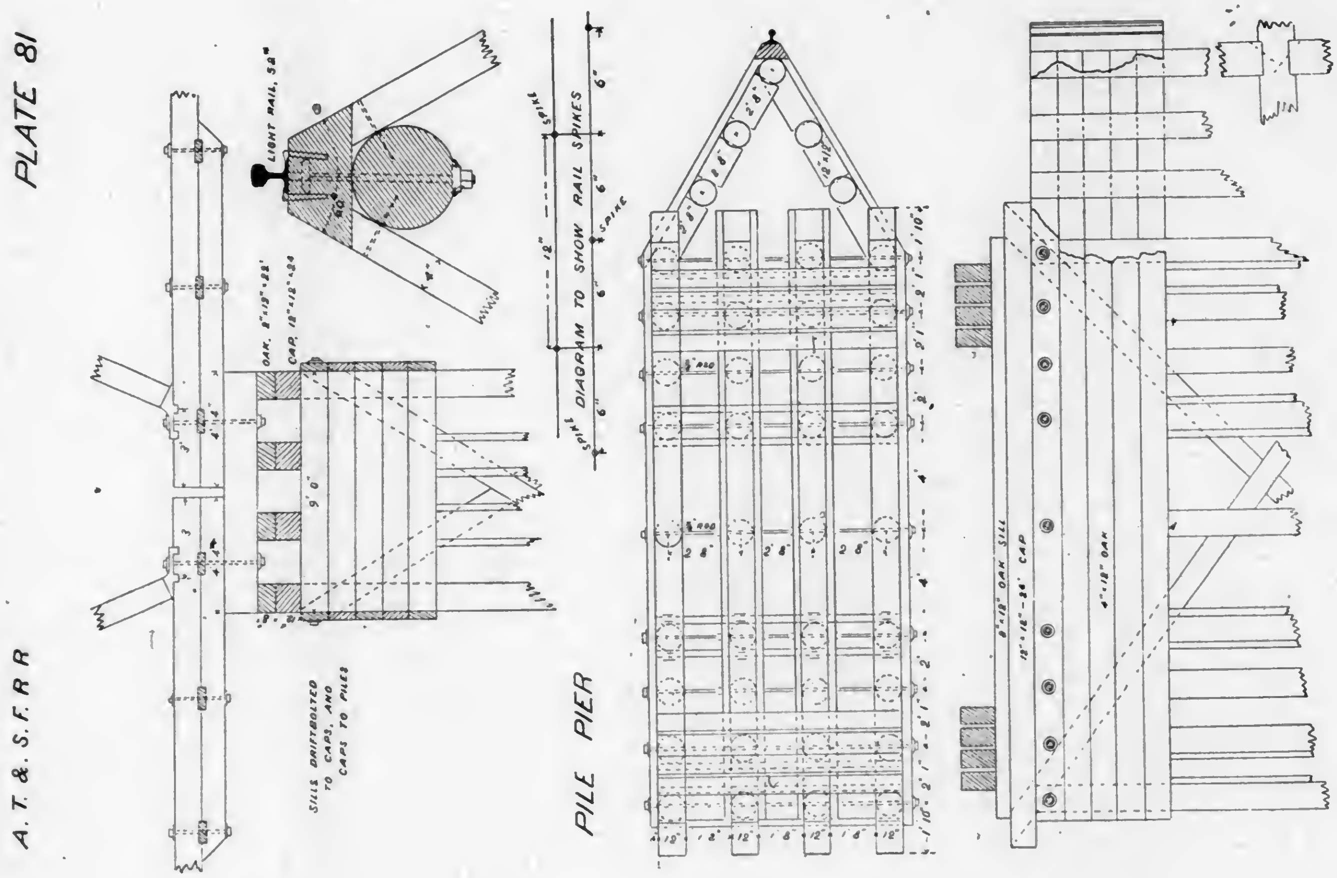


PLATE 81
A. T. & S. F. R R
PILE PIER
DIAGRAM TO SHOW RAIL SPIKES
SPIKE
SILLS DRIFTBOLTED TO CAPS, AND CAPS TO PILES
8"x12" OAK SILL
12"x12"-24' CAP
4"x12" OAK

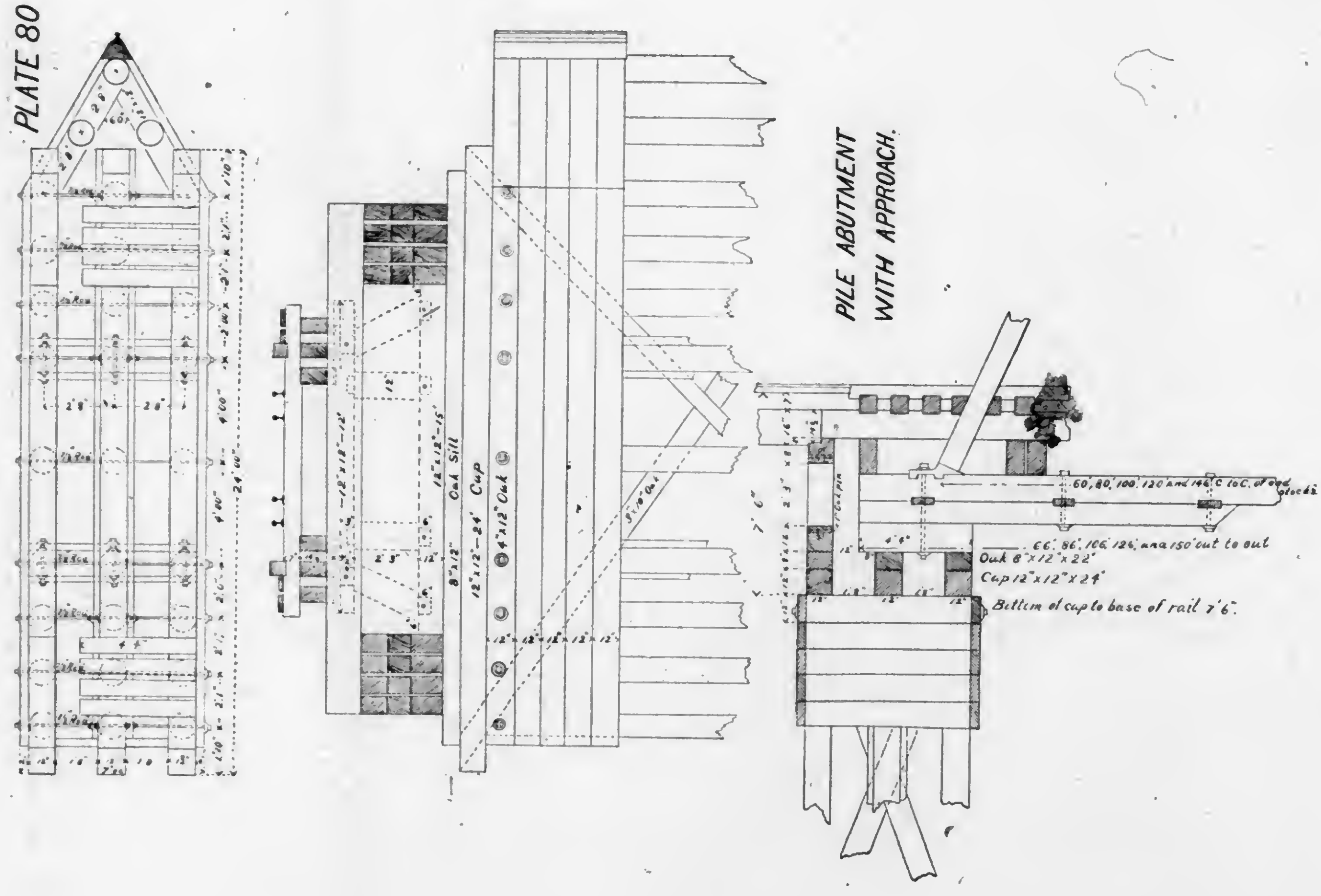
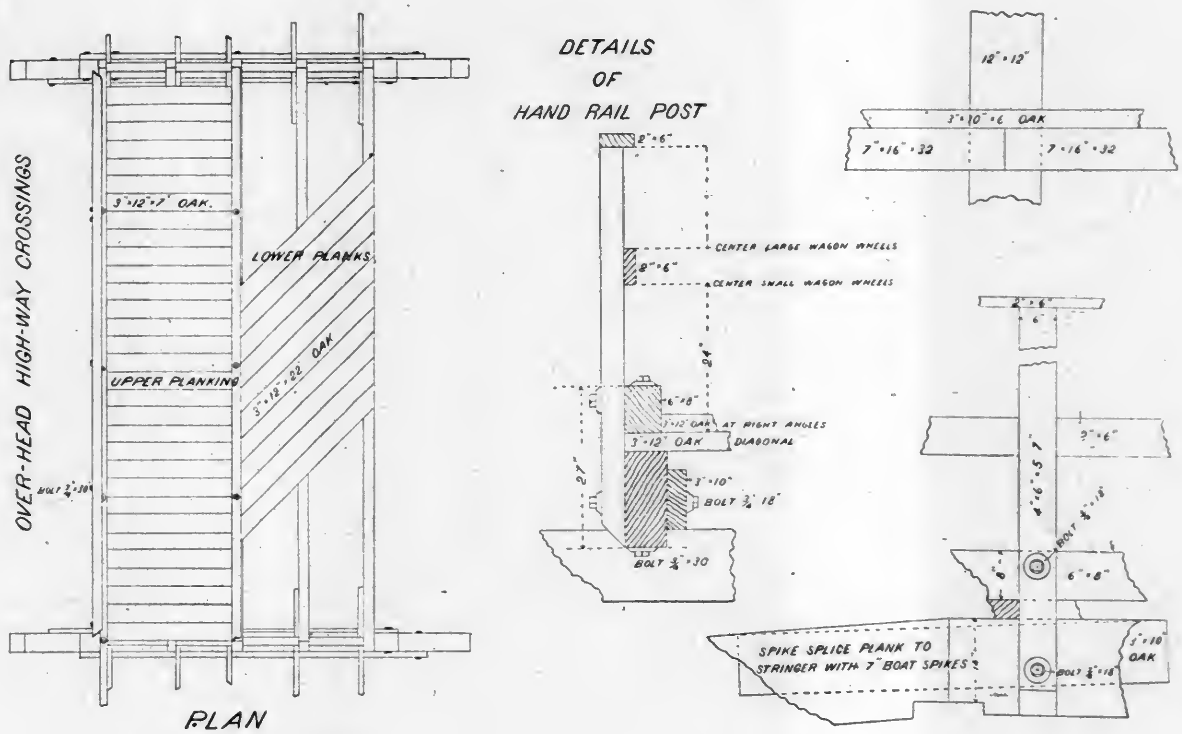


PLATE 80
PILE ABUTMENT WITH APPROACH.
Oak Sill
12"x12"-24' Cap
4"x12" Oak
60, 80, 100, 120 and 140 C to C. of end blocks
66, 86, 106, 126, and 150 cut to cut
Oak 8"x12"x22'
Cap 12"x12"x24'
Bottom of cap to base of rail 7'6".
7' 6"

PLATE 86.

OVER-HEAD HIGH-WAY CROSSINGS

A T & S F. R R.

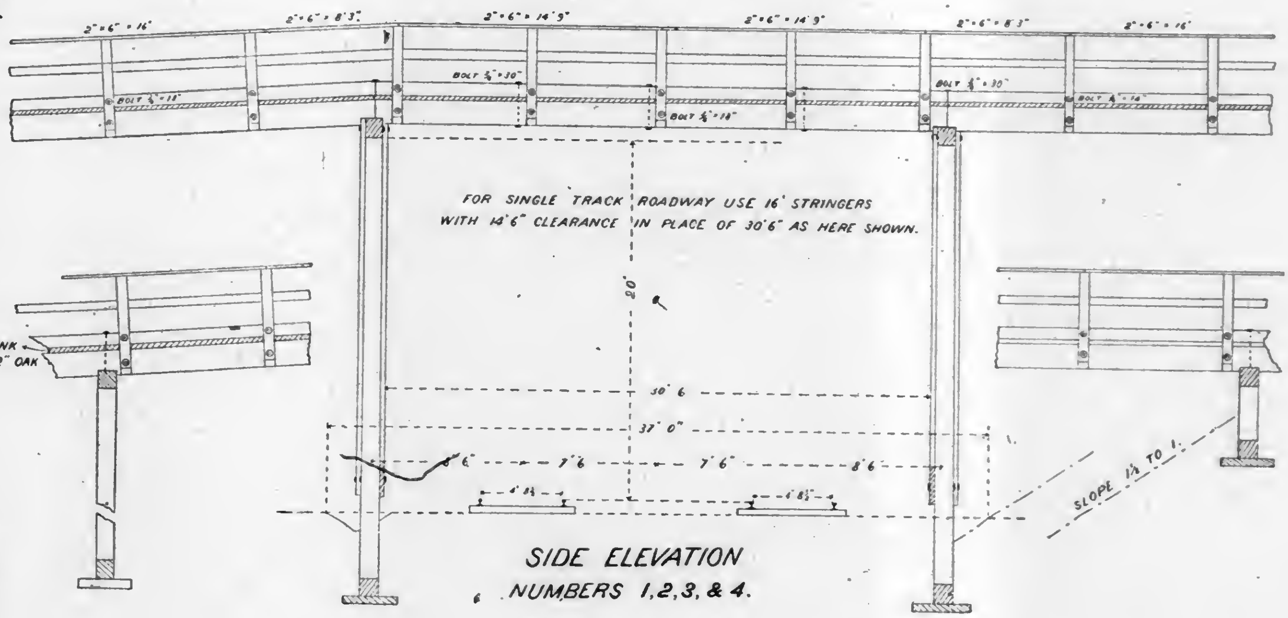


PLAN
No 2 ROAD CROSSING

PLATE 83.

A. T. & S. F. R.R.

OVER-HEAD HIGHWAY CROSSING



SIDE ELEVATION
NUMBERS 1,2,3, & 4.

spacing of the piles in the rows being as shown in the plan. The longitudinal and lateral cross-bracing is shown clearly in the plate, and the outside is planked with oak plank, 4 in. × 12 in. in size, boat-spiked to each pile. Upon the up-river end is built the "nose" or "ice-breaker." The details of this are fully shown in the plate.

The nose should be thoroughly braced at the high-water line and also at the ice-flow line by 12 in. × 12 in. pieces set between the piles and notched into them about 1½ in., as shown in fig. 3. These pieces should also be held in place by spikes driven through the outside planking. The stringer on the point of the nose should be bolted to the pile at intervals of 4 ft. with ¾-in. bolts. The rail used as a fender may be of any size most convenient. On the Atchison, Topeka & Santa Fé Railroad a 52-lb. rail is usually used. This rail should be spiked to the stringer, as shown in the diagram, every 12 in. on each side, and the spikes placed alternately. The holes for these spikes, and all the spikes used, should be bored with a ½-in. bit.

In the plans shown in the plates the bottom of the cap is always 7 ft. 6 in. below the base of the rail.

In both pile-piers and framed piers upon piles, the interior should be filled in as much as possible with stone after the track is laid. The nose and that part of the pier extending back to the point marked *A* should certainly be carefully filled with stone.

CHAPTER XXI.

OVERHEAD CROSSINGS AND BRIDGES.

On every railroad there will be required a number of small structures for overhead crossings, and in many cases it will be necessary, on account of economy, to construct these of wood. Even on the more important lines there are by-roads and farm-crossings where an expensive structure is not warranted by the nature or importance of the traffic, and where a wooden bridge will answer every purpose.

Plates 83, 84, 85, and 86 show overhead crossings of this kind as constructed on the Atchison, Topeka & Santa Fé Railroad. The general plan and details of these structures are shown very fully in the plates, and will require but little additional description. Of course this class of bridges will vary in different places, according to the surroundings and local needs, but the general type will remain substantially the same.

(TO BE CONTINUED.)

UNITED STATES NAVAL PROGRESS.

NOT much is to be said of new ships yet, as at present everything waits upon the action of Congress. Judging from the general temper of that body, however, it seems very probable that the recommendations made by the Secretary will be met, in part at least, and a liberal appropriation for new ships made.

It may be noted that the four new cruisers included in the Squadron of Evolution—the *Chicago*, *Boston*, *Atlanta*, and *Yorktown*—did well on their first voyage, and showed themselves to be excellent sea boats in a very stormy passage across the Atlantic.

Rapid progress is being made in fitting out the *Charleston* and the *Baltimore*, and those ships will soon be added to the list of our active Navy.

THE NEW ARMORED CRUISERS.

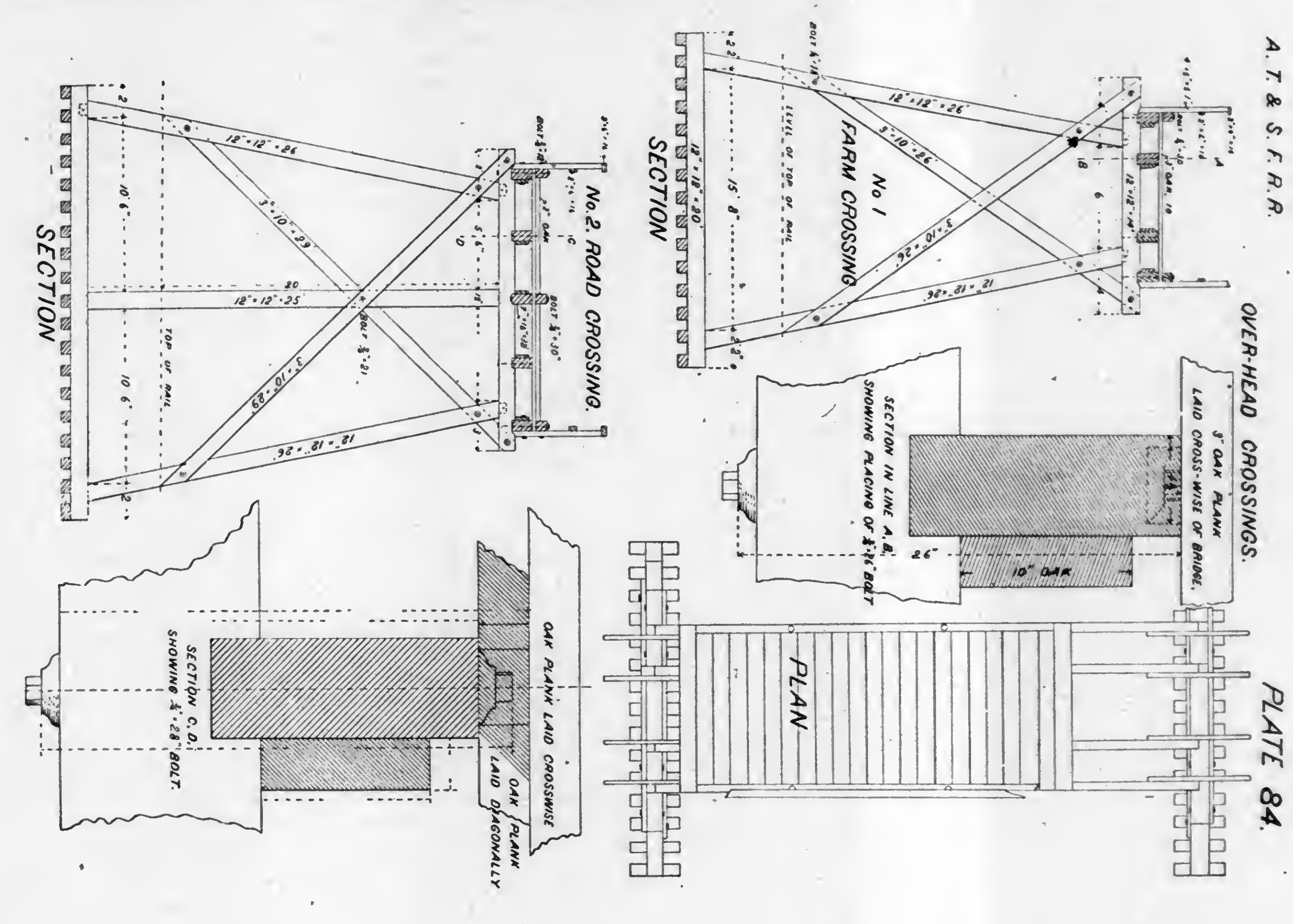
A circular has been issued by the Navy Department, addressed to the ship-builders of the country, on the subject of the 5,300-ton cruiser and the 7,500-ton armored cruiser. This circular appears in advance of the regular invitation for proposals, and is intended to convey to possible bidders such information regarding these vessels as will enable them to make up their own plans and specifications for submission under the terms of Class 2.

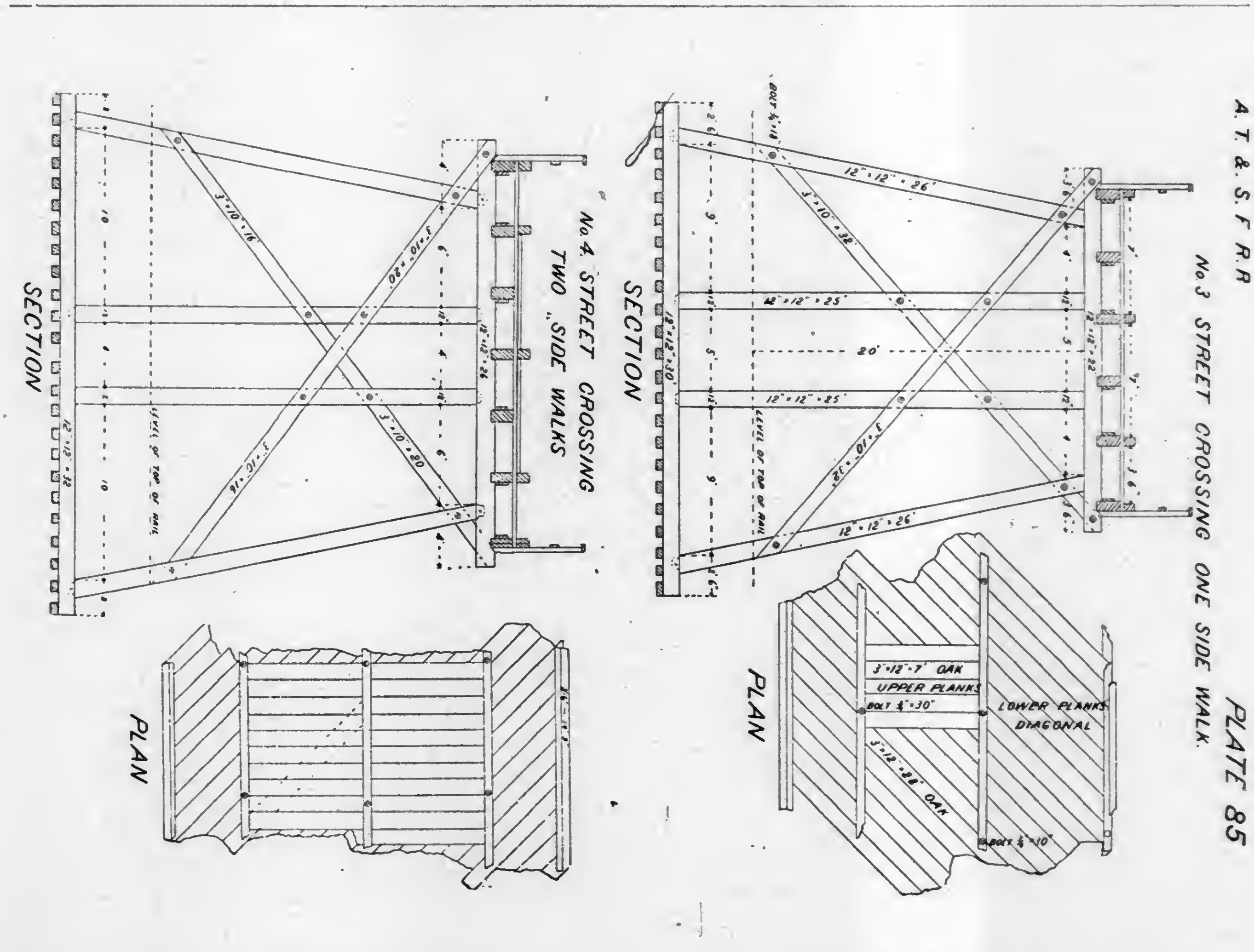
The circular prescribes for the 5,300-ton steel cruiser, which is to cost not more than $1,800,000, a maximum speed of at least 20 knots per hour, and allows a premium of $50,000 for every quarter of a knot over the guarantee, and deducts from contract price $50,000 for every quarter of a knot less than the guarantee. The main battery is to consist of two 8-in. breech-loading rifled guns, to be mounted in a barbette or casemate, with armor 4 in. in thickness, protected by a steel circular shield 4 in. in thickness, secured to the gun platform and revolving with it on a circular roller base, and ten 4-in. rapid-fire guns to be mounted under the protection of the superstructure deck, having semi-circular shields on them, which revolve with and keep the port nearly closed. At the ship's side above and below these guns further protection is had by steel plates 4 in. in thickness. The secondary battery consists of eight 6-pounder Hotchkiss, six 3-pounder Hotchkiss, two 1-pounder Hotchkiss, one 1-pounder boat mount, four 37 mm. caliber Maxim guns, six 45 mm. caliber Maxim guns. The coal supply is 1,300 tons, and the coal supply at normal displacement 400 tons. The complement is to be 25 officers and 441 men. The thickness of armor on slope over machinery is 4¾ in.; thickness of armor on flat over machinery, 2 in.; thickness of armor on slopes at ends, 3 in.; thickness of armor on flats at ends, 2 in. The total weight of main battery and ammunition is 84.42 tons; the weight of the secondary battery is 16.60 tons, and its ammunition, 39 86 tons; the weight of small arms and equipment 3.70 tons and its ammunition 10.84 tons, making total weight of armament and protection 434 tons. The electric light plant will consist of three units, each unit to have an engine, dynamo, and combination bed-plate, the combined weight of which should not exceed 2,400 lbs. The weight of all stores and fittings of the installation, including search-lights, should not exceed 30 tons.

The armored cruiser of 7,500 tons displacement, to cost not more than $3,500,000, is to exhibit a speed of 17 knots per hour. The armament of the main battery is to consist of four 11-in. breech-loading rifled guns and six 4-in. rapid-fire guns. The secondary battery is to consist of four 15-pounder Hotchkiss, four 6-pounder Hotchkiss, four 3-pounder Hotchkiss, four 1-pounder Hotchkiss, four 37 mm. caliber Maxims, four 45 mm. caliber Maxims. The coal supply is to be 1,000 tons, and at normal displacement 450 tons. The complement of the vessel is to be 25 officers and 416 men. The side armor is to be 11 in. in thickness; protection of great guns, 10.5 in.; diagonal bulkheads, 10 in.; conning-tower, 10 in.; protective deck over building, 3 in.; protective deck at ends, 2 in.; protection of auxiliary battery, 4 in. The weight of main battery will be 279 tons and its ammunition 231.04 tons; of the secondary battery, 25.80 tons, and its ammunition, 56.35 tons; of small arms and equipments, 4 tons, and its ammunition, 11.60 tons. The torpedo outfit consists of 21 Howell torpedoes, 6 launch tubes with engines, connections, etc.; 1 boat torpedo outfit, torpedo defense net, torpedo bombs, having a combined weight of 683.29 tons. The equipment outfit will weigh 238.36 tons. There are to be three complete generating sets in the electric light plant of the vessel.

These will be the first vessels armed with the Maxim gun.

Since the issue of this circular the Secretary has ordered work to be suspended on the plans of the 7,500 ton ship to allow time for Congress to authorize her increase to an 8,500 or 9,000-ton vessel. No detailed plans of the enlarged ship have been worked out yet, and it has not even been decided what type she is to be. It is most probable, however, that she will be given more armor protection and heavier guns, her 11-in. guns being supplanted by guns of 12-in. caliber. The secondary battery of rapid-fire guns would also be increased and more engine power would be given her, so as to force her speed up to 18 knots or more and make her a fast-cruising battle-ship. Another proposition is to convert her into a protected cruiser of great speed equal to or superior to the *Blake*, of the British Navy. If this plan is adopted, side-armor will be dispensed with entirely, and her vital parts will be protected by a heavy turtle-back steel deck, sufficient to deflect most of the shots that would be apt to strike her. The lines of her hull would be designed for great speed, and she would be given engines of from 13,000 to 14,000 H.P., so as to drive her through the water at a maximum speed of from 20 to 21 knots an hour. If this latter type is adopted, the


A. T. & S. F. R.R.
OVER-HEAD CROSSINGS.
PLATE 84.
No 1
FARM CROSSING
SECTION
No. 2. ROAD CROSSING.
SECTION
PLAN
3" OAK PLANK
LAID CROSS-WISE OF BRIDGE.
SECTION IN LINE A.B.
SHOWING PLACING OF ¾"×26" BOLT
10" OAK
OAK PLANK LAID CROSSWISE
OAK PLANK
LAID DIAGONALLY
SECTION C.D.
SHOWING ¾"×28" BOLT.
TOP OF RAIL
LEVEL OF TOP OF RAIL
12"×12"×26'
12"×12"×25'
12"×18"×26'
12"×18"×21
12"×18"×20'


A. T. & S. F R.R
No.3 STREET CROSSING ONE SIDE WALK.
PLATE 85
SECTION
PLAN
No.4. STREET CROSSING
TWO SIDE WALKS
SECTION
PLAN
3"×12"×7' OAK
UPPER PLANKS
BOLT ¾"×30"
LOWER PLANKS
DIAGONAL
3"×12"×28' OAK
BOLT ¾"×10"
LEVEL OF TOP OF RAIL
12"×12"×26'
12"×12"×25'
3"×10"×32'
20'

weight of the vessel's battery will be greatly reduced, and Instead of four 11-in. guns her largest weapons will probably be two 10-in. guns.

THE NEW TORPEDO-BOAT.

The torpedo-boat *Cushing*, built by the Herreshoffs at Bristol, R. I., is required by contract to make 22 knots an hour. The builders will receive a premium of $1,500 for each quarter-knot up to 24 knots which the vessel may make, and $2,000 for each quarter-knot over 24 knots, should that speed be exceeded.

The boat is 138 ft. long, 15 ft. beam, 10 ft. deep and 4 ft. 4 in. draft; it is built entirely of steel. The armament will consist of two 14-in. torpedo-tubes at the bow, with two other torpedo-tubes and two small rapid-fire guns on deck.

The boat has two screws, each driven by a separate engine. These engines are of the quadruple-expansion pattern, with five cylinders. The high-pressure cylinder is 11½ in. in diameter; first intermediate cylinder, 16 in.; second intermediate cylinder, 22 in.; two low-pressure cylinders, each 22 in.; all being 15-in. stroke. The propellers are of manganese bronze, 4 ft. 2 in. in diameter and 8 ft. pitch. Steam is furnished by two Thornycroft water-tube boilers, built by the Continental Iron Works, of Brooklyn, N. Y. Each boiler has 34 sq. ft. grate surface and 1,800 ft. heating surface. Forced draft will be supplied by a fan-blower. There is an electric light plant for lighting the boat and for search-lights.

THE NAVAL RESERVE.

An abstract of the important bill introduced in the Senate by Mr. Frye, of Maine, to provide for the establishment of a reserve force of cruisers for the Navy is as follows:

"The Postmaster-General is authorized to enter into contracts for a term of years, not less than five nor more than ten, for the carrying of the mails between the ports of the United States and foreign ports in iron and steel American owned and built steamships. The service is to be let to the lowest bidder. These steamships shall be officered by American citizens, manned by crews at least one-half of whom shall be American citizens, and constructed after the latest and most improved models. The steamships will be of two classes. The first shall be iron or steel screw steamships, with a speed of at least 18 nautical miles an hour, and a gross registered tonnage of not less than 4,000 tons; and no vessel except of the first class shall be accepted for mail service between the United States and Great Britain. The second class shall be iron or steel steamships, not less than 2,000 tons gross, capable of a speed of 14 nautical miles an hour.

"All steamships hereafter built for this purpose shall be constructed on models and according to plans and specifications approved by the Secretary of the Navy, and of sufficient strength and stability to carry and sustain the operation of at least four effective rifled cannon of a caliber not less than 6 in., to be specially adapted to conversion for use as transports or cruisers in the event of war. The compensation for mail service by the first-class ships shall not exceed $6 a mile for outward voyage, and for the second class ships not more than $4 a mile. A United States mail messenger shall be transported on each ship free of charge, with the usual cabin accommodation, to receive, take in charge, and deliver the mails. Officers of the Navy may, with the consent of the Secretary, be granted furlough and accept employment on these ships, receiving as pay furlough pay and such additional amount as the contractor and the officer may agree to.

"Each of these ships shall take an American-born boy as cadet or apprentice for each 1,000 gross register tons and one for each majority fraction, who shall be ranked as a petty officer, trained as a sailor, and receive reasonable pay for his services. In event of war such steamers may be taken by the United States for use as transports or cruisers, upon payment to the owners of the value of the same, to be ascertained by appraisal."

ORDNANCE AND ARMOR-PLATES.

The Secretary of the Navy has issued advertisements asking bids for supplying eight 16-in. gun-lathes for the Naval Ordnance Foundry in the Washington Navy Yard. Bidders may submit proposals for lathes constructed in accordance with the plans of the Bureau of Ordnance, or they may submit designs of their own. These lathes will be an immediate addition to the plan of the Ordnance Bureau. Thus far it has not been possible to handle guns of over 10-in. caliber in the Washington Yard, but the new lathes and the 110-ton traveling crane now under construction will make it possible to finish guns up to 16-in. caliber. Forgings are now coming in under the contracts made some time ago, and it is understood that there will be no difficulty in supplying the guns for the new vessels as fast as they are wanted.

The Navy Department has also given notice of competitive trials of armor-plates to be held at the Naval Proving Grounds at Annapolis, and manufacturers are invited to submit plates for trial. This must be 6 ft. by 8 ft. in size and 10½ in. in thickness. Manufacturers desiring to compete must notify the Department of their intention to do so not later than February 10 next.

HORATIO ALLEN.

HORATIO ALLEN, who for more than half a century has been known as a distinguished engineer, died on the evening of New Year's Day at his residence, "Homewood," near South Orange, N. J. For nearly a year he had been confined to his house by the infirmities of age, and, at last, when the vital forces had been transformed into the work of a lifetime, his days were ended peacefully, and his eventful career was finished.

He was born in Schenectady, N. Y., in 1802, and was consequently 86 years old last year. He was the son of Dr. Benjamin Allen and Mary Benedict Allen. His father was the principal of a large school at Hyde Park, N. Y. The son therefore had excellent educational advantages in early life, and was sent to Columbia College in New York City, from which he graduated about 1820, taking high rank in mathematics. He studied law at first, but after a short time decided to make engineering his work, and entered the employment of the Delaware & Hudson Canal Company under Judge Wright, then Constructing Engineer of the line. In 1824 he received an appointment on the Chesapeake & Delaware Canal. He was sent to St. George's, Del., and within two weeks was placed in full charge of a party. In the autumn of 1824 he was made Resident Engineer of that work. A year later he was appointed Resident Engineer of the summit level of the Delaware & Hudson Canal, under John B. Jervis, then Chief Engineer of the Company. While Mr. Allen was engaged in this position his attention, and that of other engineers in America, was attracted to the performance of locomotives in England. His early relation to these events may best be told in his own words, quoted from a pamphlet, with the title "The Railroad Era," which he published a few years ago. In this he said:

"During the years 1826 and 1827 the use of the locomotive on the Stockton & Darlington Road, England, had become known to many, and especially to civil engineers in this country, and among others to myself, then a Resident Engineer on the line of the Delaware & Hudson Canal, the great engineering enterprise of the time, the first of the great works, canal and railroad, that were to bring the anthracite coal of the valley of the Susquehanna into the valleys of the Delaware and of the Hudson and to the ocean.

"Such consideration as was within my power led me to a decided conviction as to the future of the locomotive as the tractive motive power on railroads for general freight and passenger transportation, as it had begun to be for mine transportation. . . .

"Early in the year 1827 I had given all the attention that it was in my power to give, and having come to conclusions as to the locomotive, that all subsequent experience has confirmed, and believing that the future of the civil engineer lay in a great and most attractive degree in the direction of the coming railroad era, I decided to go to the only place where a locomotive was in daily operation and could be studied in all its practical details.

"Closing my service on the Delaware & Hudson Canal, some two months were appropriated to certain objects and

interests, after which I was again in New York, preparatory to going to England.

"On my return to New York from these visits, I found that it had been decided by the Delaware & Hudson Canal Company to intrust to me, first, the having made in England for that Company the railroad iron required for their railroad. . . .

"This action of the Delaware & Hudson Canal Company was on the report of their Chief Engineer, John B. Jervis, and thus it occurred that the first order for a locomotive engine, after the locomotives on the Stockton & Darlington Road were at work, came from an American company, on the report of an American civil engineer."

The following are copies of some old papers, which were preserved by Mr. Allen, relating to this commission. One of them is indorsed:

"1828.--EXTRACTS FROM THE REPORT OF THE COMMITTEE SANCTIONED BY THE BOARD REFERRED TO IN MY LETTER TO MR. ALLEN.

"J. BOLTON, *President.*"

The following is a copy of the paper which evidently embodies the instructions of a committee to Mr. Allen for the execution of his commission in England:

EXTRACT, ETC.

That Horatio Allen, Esq., Civil Engineer, has agreed to go to England as the Agent of the Company to procure the railroad plates and perform such other services in relation thereto as may be required of him. The Company to pay his passage out and home and his expenses during his stay, allowing him to remain three months, for the purpose of attending to the Company's business and acquiring information. His expenses on the whole not to exceed $900, and on his return he will communicate to the Company all the information he may acquire that may be useful to the work in which they are engaged.

That they deem it advisable to authorize Mr. Allen to procure one locomotive engine complete, as a pattern, and that the Chief Engineer is making inquiries to ascertain whether it may not be expedient to authorize the construction of all the locomotive engines in England.

That it is deemed advisable to suspend the making of the wheels and axles of the coal wagons until information be received from Mr. Allen of the cost of those articles in England, and of the latest improvements that have been adopted in the manner of connecting the wheels and axles. The engineer in his report recommends wheels of $3\frac{1}{2}$ ft. diameter; but his mind is not definitely made up on this point. He will investigate the matter further and report the result.

That Mr. Allen be instructed to procure the railroad plates of the length recommended in the report of the Chief Engineer; the ends to be cut and fitted into each other and the holes made for the fastenings, as recommended in the same report; that the rounding of the edges of the plates will be advantageous, but is not so indispensable as to induce the committee to recommend that the plates be thus formed without limitation as to the increase of expense and time that may be required therefor.

That there is much force in the reasoning of the Chief Engineer in favor of dispensing with any allowance for expansion and contraction of the plates, in forming the holes for the fastenings, yet the committee are of opinion that it would be safest to make such allowance, and the Chief Engineer has devised a plan for effecting it which the committee believe will be successful. This plan will be communicated to Mr. Allen and he may then be allowed very safely to adopt that or any other plan which may be found more economical.

The committee being now satisfied that an economical plan will be devised for forming the holes in the plates so as to allow for contraction and expansion, they unite in opinion with the Chief Engineer that the fastenings of the plates will be best effected with screws.

That the Chief Engineer is of opinion that on two of the levels west of the summit and one east of the summit machinery worked by engines may be advantageously substituted for the horse-power first proposed, but that the form of the country will not admit of such substitution on the other levels west of the summit.

EXTRACT FROM THE MINUTES OF JANUARY 10, 1828.
S. FLEWELLING,
Treasurer of the Delaware & Hudson Canal Company.

The rounding of the edges or omitting it is left to Mr. Allen. The last paragraph is introduced to suggest to Mr. Allen that information is wanted. In the letter to Messrs. Brown, I say: "Mr. Allen is authorized to procure such drawings of machinery and designs connected with railroads, canals, and the raising and transporting of coal as he may deem proper."

J. BOLTON.

A letter from Mr. Jervis, the Chief Engineer, which apparently accompanied the preceding "Extracts from the Report of the Committee," is endorsed:

"1828.—MR. JERVIS'S LETTER TO MR. ALLEN REFERRED TO IN MY LETTER TO MR. ALLEN.

"J. BOLTON."

The letter is as follows:

To Horatio Allen, Esq.

DEAR SIR: The Board of Managers for the Delaware & Hudson Canal Company, having made an engagement with you to proceed to England as their Agent to procure certain articles for the proposed Carbondale Railroad, and also such information as may be useful in the construction and management of said railroad; I am therefore directed by the said Board of Managers to furnish you such information and instruction as will further their object.

The Board of Managers have determined on procuring their iron plates for the railway tracks as one item.

The length of plates to be from 12 to 14 ft., as you may find most convenient for rolling them through on the edges; to be $2\frac{1}{4}$ in. wide on the bottom and 2 in. on the upper surface and $\frac{1}{2}$ in. thick, with the upper edges rounded and the end finished as represented on the plan. Holes to be drilled for the screws with countersunk heads at each end of every bar and at intermediate points 18 in. apart. After the holes and countersink have been drilled in a circular form, then a rimmer of the proper form to fit the countersink and hole for the neck of the screw to be put in to cut the aperture longitudinally. To effect this the rimmer must be put in and then firmly fixed to its position and the bar made to move toward it in the direction of its length, about $\frac{1}{8}$ or $\frac{1}{9}$ of an inch. This may be reduced as you recede from its end to the center; but as it is likely to create confusion to attempt any economy in varying the length to be rimmed, it will be better to have all the holes rimmed alike.

LOCOMOTIVE STEAM ENGINES.

It is desirable, in order to dispense with the tender carriages, to have a water tank fixed to the engine carriage that will contain about 100 gals. If made in two parts, of sheet-iron, it will weigh, with its hanging or supporting irons, about 250 lbs., and the water about 1,000 lbs., making together about 1,250 lbs. To increase the capacity of the tank to 120 or 150 gals. would add but little to its weight. I see no difficulty in attaching such a tank to the engine carriage, and you will determine whether it will be most convenient to support it over the axles or suspend it under them; being divided into two equal parts it may be placed on each side of the revolving chains, with a pipe to pass the water from one to the other. If the weight of the engine should admit of it, it will be preferable to make the tank sufficient to contain 120 to 150 gals. The pump of the engine to supply the boiler with water from the tank should be calculated to work one-quarter faster than necessary for a regular supply in order to provide for a waste of steam when the engine stops, and to be constructed so as to work by hand, which will be necessary at certain times. The boiler will not require a capacity for any considerable quantity of water beyond what is necessary for the work, as the pump will regularly supply, except when the carriage stops at the end of the road, at which time it is supposed to have supplied a surplus adequate to the waste that will take place during delay. The stoppages may be estimated at one-quarter the whole time; on the shortest section 10 minutes, on the longest 20 minutes. The weight of engine, carriage, and water, if placed on six wheels, to be from 6 to 7 tons, but $6\frac{1}{2}$ tons preferred. If it should be found that a six-wheel carriage has any important difficulty in working well on curved roads, that in your judgment would counterbalance the advantage of a heavier engine and give the preference to the four-wheel carriage, then the weight must not exceed $5\frac{1}{2}$ tons; but the six-wheel carriage will be preferred if it can be made to work. If a six-wheel carriage the axle need not exceed $2\frac{3}{4}$ or 3 in. at the bearing. The diameter of the wheels 3 to 4 ft., as you find most approved from experiments in England for similar purposes and rate of traveling, say $3\frac{1}{2}$ to 5 miles per hour. The power of the engine, such as will carry 800 lbs., at the rate of 4 miles the hour, or what is nearly the same thing, 640 lbs. at the rate of 5 miles the hour. I think about 4 miles the hour a good velocity for the work contemplated, but the range above given will allow you to vary this, as you may find most expedient, in relation to several points that you will perceive to have a bearing on this question. The diameter of the wheels of the engine carriage will affect the velocity, or distance

traveled at a given number of strokes of the engine, but I would take 3 ft. as the minimum diameter and make them as much larger as the arrangement of the working parts will admit, without giving too great a velocity. The length of the stroke must depend something on the facilities of securing firmness to the cylinder, and this may lead you to prefer a larger or smaller diameter for the cylinder; the pressure of the steam has also a bearing on the question; on account of the weight I think the cylinder should not exceed 8 in.

To elucidate my views more fully, I will state what appears to me a suitable arrangement. Length of stroke 27 in. and 40 strokes per minute; two 8-in. cylinders, pressure of steam 60 lbs. per square in. This will give 2,400 revolutions per hour. Area of cylinder $8^2 \times .7854 \times 2 = 100.5$ sq. in. A double stroke equal 4.5 ft.; then 100 5 $\times$ 4.5 $\times$ 60 $\times$ 2,400 =65,124,000 lbs. raised 1 ft. But by the experiments of Wood we may only take 30 per cent. and 65,124,000 $\times$ .30 = 19 537,200 raised 1 ft., which is equivalent to 800 lbs. carried or raised 24,421 ft., equal to 4.62 miles per hour. Now 24 421 $\div$ 2,400 = 10.17 ft., the space moved over by the carriage at each revolution of the engine, and of course the diameter of the wheel must be 3.25 ft. If there should appear a difficulty in securing a cylinder with proper stability for the above length of 27 in., it may be advisable to make the stroke 25 in. Then, all other points remaining the same, the power of the engine will only be equal to carry the same load of 800 lbs. $4\frac{1}{4}$ miles, and the wheels of the carriage must be reduced to 3 ft. diameter. It may be found expedient to have larger wheels and travel at the rate of 5 miles per hour, with a proportional load. Suppose cylinder $7\frac{1}{2}$ in. diameter, 27 in. stroke, pressure 60 lbs., 40 double strokes per minute, or 2,400 per hour. Then $7.5^2 \times .7854 \times 2 = 88.34$, say area of two cylinders 88 $\times$ 60 $\times$ 4.5 $\times$ 2,400 = 57,224,000 lbs. raised 1 ft.; 30 per cent. is 17,107,200 lbs. raised 1 ft., and is equivalent to 648 lbs. carried 5 miles, will require the carriage-wheel to be $3\frac{1}{2}$ ft. diameter. The power of the engine will be a trifle less than the last calculation before it. But if you find it necessary to reduce the length of stroke to 25 in., it will not give the power we prefer with less than 8-in. cylinders. If, as before observed, you find difficulties that have not been anticipated in working a six-wheel carriage, that compels the use of a four-wheel carriage, the power of the engine must be reduced in order to reduce the weight of the engine and the carriage. If you can avoid it, I think it better not to calculate for more than 40 double strokes per minute. I believe the above will give you a sufficient view of what will answer our object, and you must vary as you find the experience of England and your own judgment may direct. I am of opinion that the furnace had better be of the oval form laid flat, otherwise the furnace may be the same as for bituminous coal. It is supposed anthracite coal does not require so high a chimney as other fuel, but I am not possessed of any particular facts on this subject; I presume you can have the chimney so constructed that an additional piece may be attached if it is found on trial to require it. On this presumption I would not have it more than 10 ft. high. As the height of chimney will affect the calculai on of bridges, it is advisable to understand this question as early as possible.

The width in the clear between the rails is 4 ft. 3 in. The greatest curvature of that part of the road on which locomotive engines are to be used is that which gives a versed sine of 1 ft. on a chord of 59 ft.; but there is only a single instance of this curvature, arc of 15 chains. The curvature which occurs in several instances is a versed sine of 1 ft. on a chord of 66 ft. A 10-ft. chord exactly $\frac{1}{4}$ in.

It is determined by the Board that you will procure from England one locomotive engine with carriage complete for work. The three others that will be wanted to depend on the cost at which they can be obtained and delivered at New York. It is supposed that they can be obtained of American manufacturers for $1,800, and I presume it will not be economy to procure them from England at a greater cost, unless you perceive a superiority in the workmanship of English engines that in your opinion will justify the additional cost.

As a preliminary step I should advise, previous to the purchase of the locomotive steam engine, that you visit the Killingworth Railroad near Coventry, the Hetton Railroad, and Darlington & Stockton Road; the two latter are near Sunderland. At Killingworth the locomotive engine is said to have been in regular use (working by the adhesion of the wheels) since the year 1814; but the Hetton Road is more in the character of the proposed work.

Although I am strongly of opinion that this will be the most convenient and economical power for the contemplated railroad, still you will perceive the propriety of availing ourselves of the experience of others in reference to its actual utility. If on examination you should find essential difficulties that we have not apprehended in the use of this means of transportation, and such as in your judgment would counterbalance their advantages, then it will be advisable not to make an engagement, but to communicate the result of your observations as early as possible.

RAILROAD CARRIAGES.

Inquire respecting the relative advantages of the fixed and revolving axle of common railway carriages; their operation on curved roads; the methods and facility of applying the brake; the manner of constructing and securing the axle to the wheel in both cases; facilities for oiling; the width of rim or track of wheels as compared to the width of rail; thickness, depth of projection and form of flange; breadth and thickness of spokes of cast and wrought iron; manner of handling and fastening the door in the bottom of the carriage to facilitate unloading coal.

It is deemed advisable to ascertain the cost of iron axle trees for the coal carriages made of iron equal in quality to Swedes or Russia iron, the bar $2\frac{1}{4}$ in. square and the bearing $2\frac{1}{4}$ in. diameter turned smooth. State the cost distinct for revolving and fixed axles; as you will perceive, the fixed axle will, on account of its longer bearing in the nave of the wheels, require more expense in turning. Examine whether fixed axles are tapered from the shoulder to the outer bearing in the nave, or whether the axle is of uniform diameter through the nave of the wheel, and in what manner the wheel is secured to the axle, and box of carriage through the axle.

Very respectfully, your friend and obedient servant,

JOHN B. JERVIS.

NEW YORK, January 16th, 1828.

The duties, say $27\frac{1}{2}$ per cent., exchange, interest, and other charges, will together amount to about 45 per cent. on the cost of the engine.

"It was under these favorable circumstances," Mr. Allen says, "that I left New York in January, 1828, and within two days after my arrival at Liverpool I made the acquaintance of George Stephenson, in the most agreeable relations, and from that time, during my stay in England, I received from him every kindness in his power, and all the aid to what I had come so far to seek that was at his command at Liverpool on the Stockton & Darlington Railroad and at Newcastle, at that time the center of all that was in progress in railroad and locomotive matters."

To get an idea of "the state of the art" of locomotive construction at the time Mr. Allen arrived in England, in 1828, it must be remembered that it was before the celebrated trial of the *Rocket* on the Liverpool & Manchester Railway, which did not occur until October 14, 1829. The form of locomotive engine which is described in Wood's "Treatise on Railroads," and which that Author says, "with trifling modifications," was used on the Stockton & Darlington, the Killingworth, and other railroads in England, had cylindrical boilers, with hemispherical ends and a single cylindrical tube of about 2 ft. diameter, which passed through the boiler and was placed within 2 in. of the bottom. In one end of this tube the fire was placed and the other end was terminated by a chimney. In some engines this tube, instead of passing through the boiler, was made to return and pass out at the same end as the fire-grate. The engines had four wheels and two cylinders, which were placed vertically and attached to the top and partly within the boiler, and were located on the longitudinal center line of the engine, one of them directly over each axle, the piston-rods working through the top cylinder heads with a long cross-head, which extended transversely far enough so that the connecting-rods could be coupled directly to crank-pins to the outside of the wheels. The cranks on the two pairs of wheels were at first maintained at right angles to each other by an endless chain passing over cog-wheels fixed upon the axles of the engine. That Mr. Jervis contemplated some such arrangement as this is indicated by the fact that he speaks of "revolving chains" in his letter. Of these chains Mr. Wood says:

"However good in other respects, this chain had its defects, and it has been superseded by cranks and connecting-rod. By continued working the chain was apt to stretch, and a contrivance was resorted to, of the removal of the chairs (?) from each other, to tighten the chain; but as this could only be done at certain periods, the chain was frequently getting slack. When this took place, and when the full power of one of the cylinders was applied upon one pair of wheels, while the other connecting-rod was upon the center, and therefore not capable of acting at all upon the other wheels, the rotation of the latter depended upon

the action of the chains; if the chain was, therefore, slack, it occasioned a slipping of the wheel until the links of the chain laid hold on the projection of this wheel in the direction in which the chain was moving round, and this slipping alternately occurred by each of the wheels in succession, as they became a predominant moving power. The chain was therefore laid aside."

To maintain the cranks on the two pairs of wheels at right angles to each other, "returned cranks" were attached to the outer ends of the crank-pins of one pair of wheels. These return cranks had what may be called secondary pins on their outer ends, which were placed at right angles to the main pin. These secondary pins were connected by coupling rods to the main pins on the other pair of wheels, and thus the two sets of main pins on the two pairs of wheels were kept at right angles to each other.

It should be observed that when Mr. Allen arrived in England the use of the multitubular boiler in locomotive engines was unknown, or was only talked about. In the engraving of the Killingworth engine in Wood's "Treatise," he shows and describes an exhaust-pipe which "is opened into the chimney, and turns up within it;" but the value of the steam blast was then not recognized. The locomotives which were known in America at that date were those which have been described. It is therefore not remarkable that Mr. Allen, then only 27 years of age, and feeling the responsibility of his position, should be governed by the instructions which he received when he left home. He therefore ordered of Messrs. Foster, Rastrick & Company, of Stourbridge, one locomotive of the Stockton & Darlington type, which was the engine that afterward had the distinction of being the first one that was ever run in America. It had four coupled wheels, fig. 1, all drivers, driven by two vertical cylinders, with 36-in. stroke, placed at the back on each side of the boiler. The motion of the piston was transferred through two grasshopper beams above the cylinders, and from those beams by connecting-rods to the crank-pins on the wheels. The front end of the beam was supported by a pair of radius rods which formed a parallel motion. The spokes of the wheels were heavy oak timbers, strengthened by an iron ring bolted to the spokes midway between the hub and felloes, and the latter was made of strong timber capped by a wrought-iron tire. From the illustrations of this engine which have survived, the cranks on each pair of wheels were apparently at right angles to each other, otherwise it is not clear how the engine could start when they were on one of the dead points. The boiler was cylindrical and had several large flues inside.

After Mr. Allen arrived in England, as already stated, he made the acquaintance of George Stephenson, and from him received much valuable aid and advice. He visited Liverpool, the Stockton & Darlington Railway, and Newcastle. Locomotive engines had then been in successful use since 1814, and the subject of railroads was attracting great attention, not only in that country, but in America and the whole civilized world as well.

The following extract from a report of the Second General Meeting of the Liverpool & Manchester Railway, dated March 27, 1829, will show how the subject was regarded. In this report it is said:

The nature of the *power* to be used for the conveyance of goods and passengers becomes now a question of great moment, on whatever principle the carrying department may be conducted. After due consideration the engineer has been authorized to prepare a locomotive engine, which from the nature of its construction, and from the experiments already made, he is of opinion will be effective for the purposes of the Company, without proving an annoyance to the public. In the course of the ensuing summer it is intended to make trials on a large scale, so as to ascertain the sufficiency, in all respects, of this important machine. On this subject, as on every other connected with the execution of the important task committed to his charge, the Directors have every confidence in Mr. Stephenson, their Principal Engineer, whose ability and unwearied activity they are glad of this opportunity to acknowledge.

On his arrival in England Mr. Allen found, as Mr. Wood, in the preface to his treatise says, that "The eyes of the whole scientific world were upon the great work of the Liverpool & Manchester Railway;" and as another writer of that period reported, "discoveries were daily made of new principles applicable to locomotives, and, extraordinary as they now are, in their power and velocity, great improvements may yet be reasonably anticipated." In England Mr. Allen spent considerable time in visiting the different roads then in operation, and in studying the performance of the locomotives in use. The kind of power to be used on the Liverpool & Manchester Railway was regarded as a question of great moment. In the spring of the year 1829 the Directors of that Company

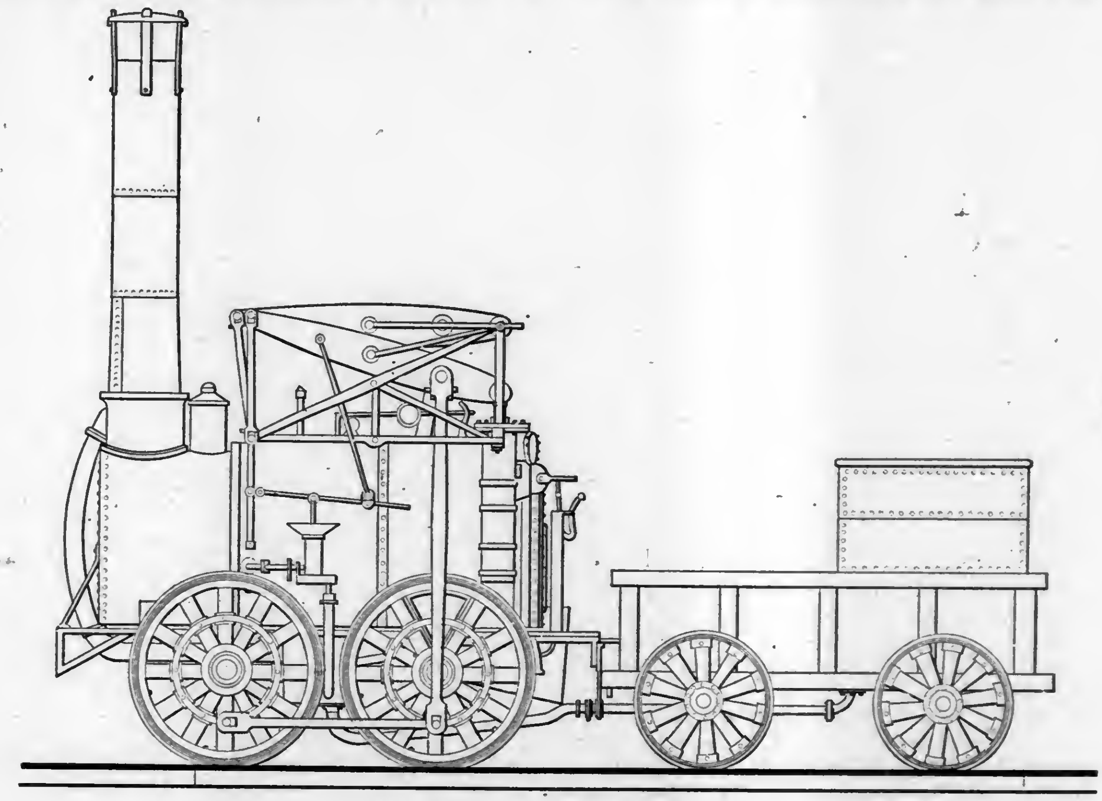


Fig. 1.

THE "STOURBRIDGE LION."

sent a deputation of their body to visit the lines where different varieties of motive power were employed. The only conclusion which they came to appeared to have been that, from the great amount of traffic anticipated upon the line, horses were inapplicable. The contest then being between locomotive and fixed engines, in order to determine which of the two was the most suitable for the purpose, the Directors resolved to employ two practical engineers, Mr. James Walker and Mr. John W. Rastrick, to report which, under all circumstances, was the best description of moving power to be used. They reported against locomotive and in favor of stationary engines. Notwithstanding this report, the Directors did not feel themselves able to come to a decision on the subject—a leaning in favor of locomotive engines existing, it was said, in a majority of the Directors.

Mr. Allen made a contract with Messrs. Stephenson & Company, of Newcastle, for two more locomotives. These engines, he said, were identical in boiler, engine plan, and appurtenances to the celebrated *Rocket*.

When completed the three engines were shipped to New York and arrived there in the winter of 1828-29. The *Stourbridge Lion*, it is said, was sent from the foot of Beach Street, in New York, to Rondout, and thence reshipped by canal to the track at Honesdale, where it made its celebrated first trip. The other two engines were for a time stored in the warehouse of Messrs. Beale & Dunscom on the East side of New York. One or both of them were there raised up so that their wheels were not in contact with the ground and were exhibited in motion with steam on as a curiosity to the public. The singular part of this is that it is not now known what ever became of these engines. All trace of them has been lost as completely as though they had been cast into the sea.*

Why the *Stourbridge Lion* was sent to Honesdale and not the other engines is not known. If one or both of these, which have since passed into oblivion, had been selected for the first run we would have had the remarkable circumstance that a trial of an engine, which Mr. Allen said was built on substantially the plan of the famous *Rocket*, would have occurred in this country *before that* celebrated event took place in England.

"It is to be regretted," said Mr. Allen, "that one of the Stephenson locomotives was not sent, and for the reason, that they were the *prototypes* of the locomotive *Rocket*, whose performance in October of the same year so astonished the world. If one of the two engines in hand ready to be sent had been the one used on August 9th, the performance of the *Rocket* in England would have been anticipated in this country."

The story of this first trial of the *Stourbridge Lion* has often been told. The engine received its name, Mr. Allen said, "from the fancy of the painter who, finding on the boiler end a circular surface, slightly convex, of nearly four feet diameter, painted on it the head of a lion in bright colors, filling the entire area."

The river and canal being closed by ice, it was not until the opening of navigation in the spring of 1829 that access was had to the railroad at Honesdale, Pa., which was then at the head of the canal and at the beginning of the railroad.

Being at liberty during July and August, Mr. Allen volunteered to go to Honesdale and take charge of the transfer of the locomotive from the canal-boat to the railroad track. Of the place where the trial was made he wrote:

"The line of road was straight for about 600 ft., being parallel with the canal, then crossing the Lackawaxen Creek, by a curve nearly a quarter of a circle long, of a radius of 750 ft., on trestle-work about 30 ft. above the creek, and from the curve extending in a line nearly straight into the woods of Pennsylvania.

"The road was formed of rails of hemlock timber in section 6 × 12 in., supported by caps of timber 10 ft. from center to center. On the surface of the rail of wood was spiked the railroad iron—a bar of rolled iron 2¼ in. wide and ½ in. thick. The road having been built of timber in long lengths, and not well seasoned, some of the rails were not exactly in their true position. Under these circumstances the feeling of the lookers-on became general that either the road would break down under the weight of the locomotive, or, if the curve was reached, that the locomotive would not keep the track, and would dash into the creek with a fall of some 30 ft.

"When the steam was of right pressure, and all was ready, I took my position on the platform of the locomotive alone, and with my hand on the throttle-valve handle, said: 'If there is any danger in this ride, it is not necessary that the life and limbs of more than one should be subjected to danger,' and felt that the time would come when I should look back with great interest to the ride then before me.

"The locomotive having no train behind it answered at once to the movement of the valve; soon the straight line was run over, the curve was reached and passed before there was time to think as to its being passed safely, and soon I was out of sight in the three miles' ride alone in the woods of Pennsylvania.

"I had never run a locomotive nor any other engine before. I have never run one since, but on August 9th, 1829, I ran that locomotive three miles and back to the place of starting, and being without experience and without a brakeman, I stopped the locomotive on its return at the place of starting. After losing the cheers of the lookers-on, the only sound, in addition to that of the exhaust steam, was that of the creaking of the timber structure.

"Over half a century passed before I again revisited the track of this first ride on this continent. Then I took care to walk over it in the very early morning, that nothing should interfere with the thoughts and the feelings that, left to themselves, would rise to the surface and bring before me the recollections of the incidents and anticipations of the past, the realization of the present, and again the anticipations of the future.

"It was a morning of wonderful beauty, and that walk alone will, in time to come, hold its place beside the memory of that ride alone over the same line more than fifty years before."

Mr. Allen always took a delight in telling of this early event in railroad history. When the enormous extent of the railroad system of this country is considered, it seems very wonderful that it was created within the lifetime of a single individual, who was an active, and, it may be said, the chief participant in the very beginning of steam locomotion in this country. Less than a year ago the venerable Captain John Ericsson ended his eventful life. He was a participant in the celebrated Rainhill trial of locomotives on the Liverpool & Manchester Railway in 1829. His life and that of Mr. Allen formed links which almost united the eighteenth and the twentieth centuries.

(TO BE CONTINUED.)

THE DEVELOPMENT OF ARMOR.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

(*Continued from page 12.*)

VIII.—PRACTICAL APPLICATION ABROAD.

The first epoch in the practical application of armor to ships began with the building, in 1854, of the five French iron-clad floating batteries, three of which figured so conspicuously at Kinburn in the following year. A number of floating batteries built upon much the same lines were constructed in England during 1854-55, and were despatched to the Crimea, but too late to take part in active operations.

These vessels, with their 4½ in. of iron armor, were unwieldy and possessed little speed, but they marked the beginning of the armor-clad fleets of to-day. The Crimean

* If any reader of this memoir has any knowledge concerning the ultimate fate of these two locomotives, he is requested to communicate it to the Editor of this paper.

War demonstrated not only the murderous effect of shell fire against wooden ships, but also the inability of such ships to reduce ordinarily strong sea-coast fortifications, and led to the laying down, in 1858, by the French Government, of the first sea-going iron-clad ship, the *Gloire*, which has been called the beginning of the second epoch in the development of armor.

As was natural, in planning the first iron-clad the inclination was to protect all the vulnerable parts, so we see this 6,000-ton frigate coming from the hands of the builders clad in a complete suit of mail. The *Gloire* was protected with laminated iron armor extending from below the water-line, where it was 5 in. in thickness, to the top of the gun-deck, where the thickness was reduced to 4½ in.—amply sufficient to resist any ordnance in use at that time.

The English laid down the keel of their first armor-clad ship in 1859, but in it they aimed to give protection only to men and guns, so the *Warrior* took the sea with a 4½-in. armor-belt, extending two-thirds of her length, and from below the water-line to above the main deck battery. But in the next war-ships laid down two years later—the *Minotaur* class—we find complete protection for both water-line and gun decks, with an increase of one inch in the thickness of the armor.

With the necessity for greater thickness of armor to match the gun, it became evident that complete protection for the sides of war-ships was no longer possible, and in the years following the laying down of the first iron clads we see a gradually increasing thickness of plate and as steady a diminution of the surface covered. The introduction of iron and steel in the construction of ships, together with the adoption of improved methods, made it possible to give relatively a greater percentage of the total tonnage to the armor, but the enormous increase in the weight of the armament more than counterbalanced the gain in this direction.

The problem that presented itself to the naval constructor was not only where to take it off—but where to put it on as well—whether protection should be given to the men and the guns, or to the water-line and the vitals. To provide for both, with the maximum displacement then considered feasible, was out of the question. In England, in the *Hercules* type, which followed the *Minotaur*, the water-belt of armor was still retained, and the guns, still in broadside, were collected in an armored central battery.

The next step in the distribution of armor was the partial or complete abandonment of the water-line belt, except in the French service, and the taking of the guns of the main battery out of broadside and putting them in heavily armored turrets. In the *Italia* and the *Lepanto* the Italians reduced to its lowest limit the armor-protected area. There is no armor belt, and aside from the armor on the central citadel, or barbette, the only vertical armored protection afforded is that given to the passages leading from the magazines to the battery.

France has, from the beginning, adhered to water-line protection—otherwise, in the grouping of guns and the providing protection for magazines, machinery, etc., by an interior armored deck, has not differed materially from the lines followed by the other powers, but the protection given to the water-line has been, of course, at the expense of that given to guns and machinery.

Within the past two years the introduction of rapid-fire guns has become an assured fact. Added to this, a series of experiments carried on both in England and France to test the effect of projectiles charged with high explosives against the unarmored sides of ships, demonstrated the frightful destruction to both men and material these projectiles would cause. These two events have led to the sudden calling of a halt in the reduction of the armor-covered area of war-ships, and a practical going back to the original type of a wholly protected iron-clad. The experiments with shell containing high explosives demonstrated that a steel plate of very moderate thickness was sufficient to cause explosion without penetration.

In speaking of armor as applied to ships, reference is made ordinarily to the plate applied vertically to the sides, as was the universal practice up to within a comparatively recent period. In recent constructions, however, another method has come into vogue, and the terms vertical and horizontal armor are used to signify the manner in which it is applied to the structures—the latter term having reference to the metal when employed as a protection for the decks, whether upon a flat or inclined surface. The substitution of horizontal for vertical armor, either in whole or in part, is becoming general. All modern war-ships now have a protective armored deck of some kind. In many of the cruisers, vertical armor is entirely omitted, and protection for the vitals is secured by steel armor applied to a protective deck at or below the water-line, supplemented by a proper disposition of coal on top.

In discussions concerning the construction of ships and the disposition of armor, the terms battle-ship—turret or barbette—belted, protected, and partially protected cruisers are constantly met with. Generally speaking, a battle-ship is a vessel of large tonnage, heavily armed and armored, and capable of taking part in any and all naval operations. Turret or barbette refer to the manner in which their heavy guns are mounted, whether in enclosed turrets or above an armored breastwork. In the first case, men, guns, carriages, and loading machinery are afforded complete protection ; in the latter, only the carriages and loading apparatus are protected, the guns themselves being in the open, unless, as in some cases, they are provided with a roof or shield against projectiles of the smaller calibers.

The belted or armored cruiser, as it name indicates, is a vessel of high speed and large coal capacity, able to take and keep the sea for a considerable length of time, and for protection has a water-line belt of armor over the whole or greater part of its length, a thick deck of horizontal armor, and a strongly armored conning-tower.

The protected cruiser, usually of smaller tonnage than its prototype, has no vertical armor, and relies for protection upon an armored deck extending from stem to stern, strengthened over the machinery and magazines with coal. In the partially protected cruiser, usually of still smaller tonnage, the protective deck stops short of the ends, and differs from the other only in the extent and thickness of the horizontal armor.

The development of armor in the direction of its practical application to war-ships can best be understood by reference to the accompanying cuts. As has been said, the first iron-clad had its sides completely covered with

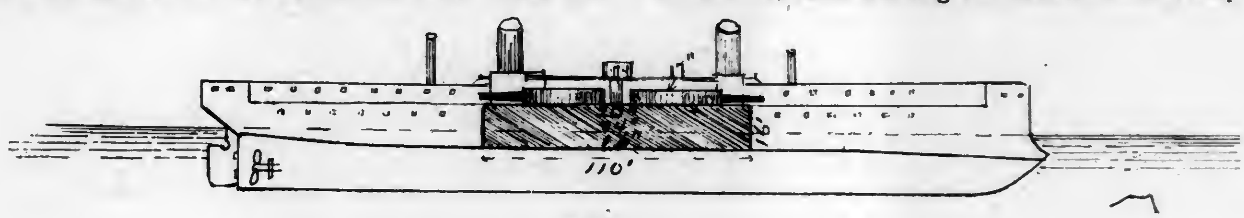
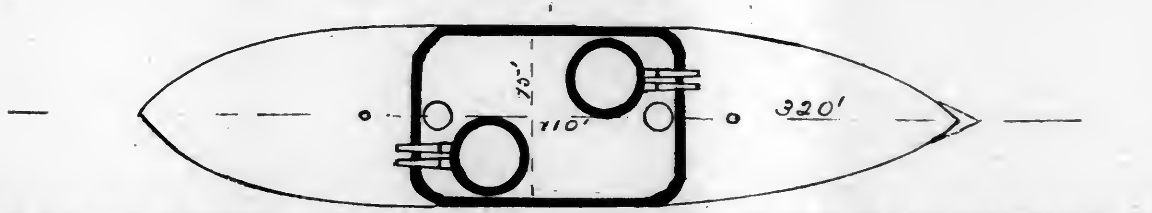


FIG. 1



armor from below the water-line to include the main-deck battery. With the necessity for thicker armor the protected area grew less, until in the English *Inflexible* (fig. 1) we have an example of extreme concentration both in guns and armor-plate. In it the water-line belt is discarded altogether. A short area amidships is provided with side armor of great thickness, the extremities of which are

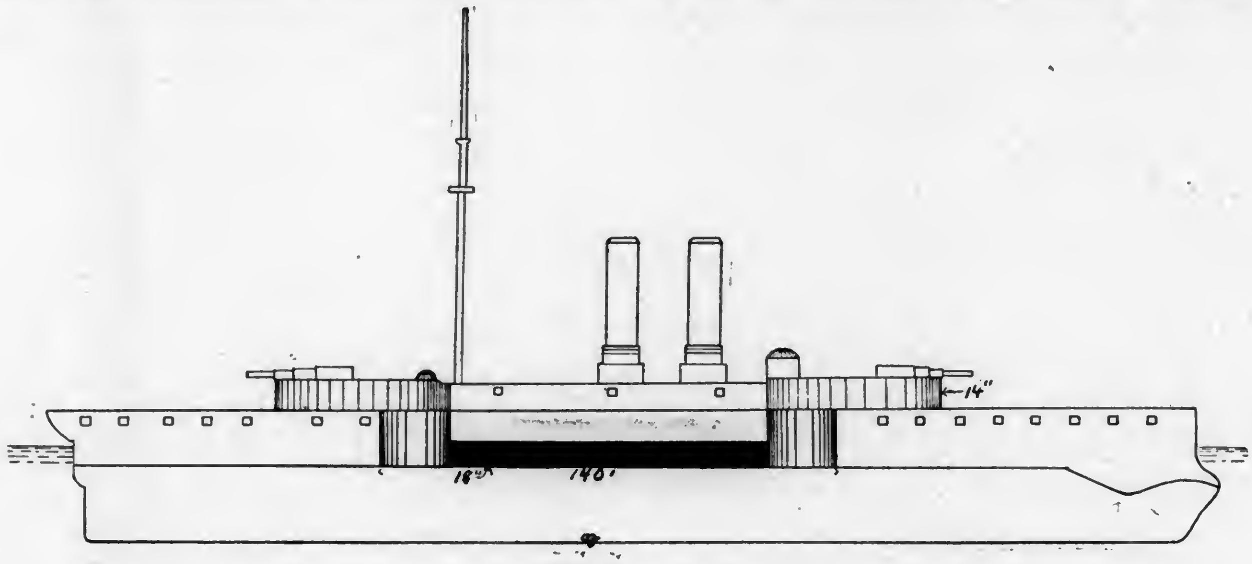


FIG. 2

connected by heavily armored transverse bulkheads, forming a central fort or citadel, wholly enclosed ; wherein are mounted all the heavy guns—four in number. Outside of the citadel, the ends are without protection. A 3-in. armored water-tight deck, extending from end to end below water, affords protection for the machinery and magazines. This substructure is so arranged in the matter of water-tight compartments and the use of cork, that it is claimed

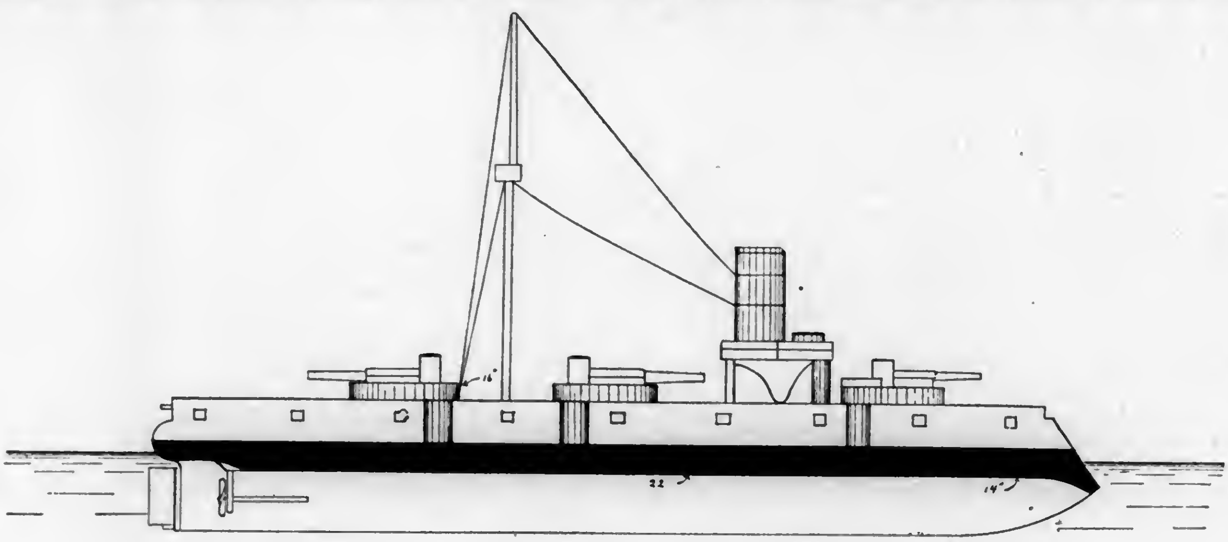
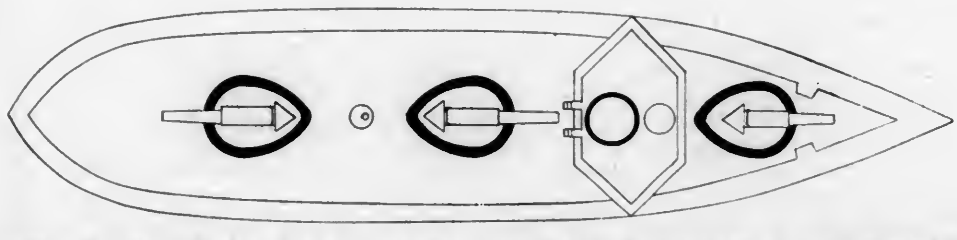


FIG 3



the end superstructures may be riddled with shot, or shot away, without destroying the fighting qualities of the ship or its seaworthiness. This ship, launched in 1876 and completed five years later, was, with her enormously thick armor and four 80-ton rifles, her nearly 12,000 tons displacement, the most powerful war-ship afloat up to within a comparatively recent date. The guns were in pairs in two turrets, placed *en echelon* within the central citadel. The citadel or side armor is of wrought iron, varying in thickness from 16 in. to 24 in. The turrets have 17-in. steel-faced (compound) armor. It has no secondary battery of importance.

The danger of concentrating the entire fighting strength of a ship into one central position, that might be destroyed by a single lucky shot, was apparent, and led to a change in construction in the ships next laid down in England. In the *Collingwood* and sister ships of the *Admiral* class (fig. 2), the gun positions were separated and placed in barbette towers 140 ft. apart, and between these barbettes was placed a heavy auxiliary armament. The barbette towers, the ammunition tubes connecting these with the magazines, and a narrow streak of armor at the water-line, running from the base of one barbette to the other, are the only portions of the ship provided with armor. The auxiliary battery between the barbettes is without protection.

In the separation of the armament, the French, in the *Amiral Baudin* (fig. 3), went to the other extreme. Here each of the three heavy guns which comprise its armament

are mounted in a separate armored barbette tower. The armor is confined to the towers, the ammunition tubes, and a narrow water-line belt. The armor is of steel, with a maximum thickness on the belt of 22 in. amidships, diminishing to 14 in. at bow and stern. The three pear-shaped barbette-towers have 16-in. armor, and are protected against machine-gun fire by umbrella-shaped shields. The armored ammunition tubes are 7 ft. in diameter. In addition to the three 75-ton breech-loading guns of the main battery, there is an auxiliary battery of twelve 14 centimeter guns mounted in broadside, but without protection. The 3 in. of armor on the armored deck is increased to 4 in. over the machinery and boilers.

(TO BE CONTINUED.)

Manufactures.

Iron Production.

THE *American Manufacturer* gives its usual tables showing the condition of the blast furnaces on January 1, and says: "In a condensed form the showing is as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	66	12,693	94	12,237
Anthracite	111	41,964	72	19,356
Bituminous	168	120,345	76	35,126
Total	345	175,002	242	66,719

"This month there is another notable increase in the number of furnaces in blast and their capacities.

"The total number of furnaces in operation on January 1 was 345, and on December 1 it was 337, showing a gain of 8 furnaces in blast, the same gain as was made in December over the previous month.

"The increase in the capacity of the furnaces in blast is from 166,955 tons on December 1, to 175,002 tons on January 1, a gain of 8,047 tons.

"This is quite a remarkable showing, and indicates that the furnaces are being pushed to meet the requirements of a large demand for pig iron. A number of furnaces which were idle for months on account of the unsatisfactory condition of the iron market are repairing and will blow in as soon as possible, while not a few of these furnaces have already done so.

"The summary given below shows the condition of the blast furnaces of the country on January 1, 1890, compared with January 1, 1889:

	Jan. 1, 1890.		Jan. 1, 1889.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	66	12,693	71	13,213
Anthracite	111	41,964	108	31,837
Bituminous	168	120,345	154	97,117
Total	345	175,002	333	142,167

"The above shows 5 less charcoal furnaces in blast January 1, 1890, than on January 1, 1889, and the weekly capacity is 520 tons less.

"There are 3 more anthracite furnaces in blast, and the weekly capacity is 10,127 tons greater.

"There are 14 more bituminous furnaces in blast, with the weekly capacity increased 23,228 tons."

Cars.

THE Elliot Car Works, Gadsden, Ala., have recently filled an order for eight cabouse cars, and a number of coal and box cars for the Alabama Great Southern Railroad.

THE Litchfield Car Company, Litchfield, Ill., is building 2,000 box cars for the Cleveland, Cincinnati, Chicago & St. Louis Railroad.

THE Dunham Manufacturing Company, Boston, reports an unusually large number of orders for car-doors. Over 15,000 of the Dunham storm-proof doors are now in use; they are found on the Grand Trunk, the Chesapeake & Ohio, the Lehigh Valley, the Northern Pacific, the Canadian Pacific, the Atchison, Topeka & Santa Fé, the Lake Shore & Michigan Southern, the Wabash, the Chicago, Burlington & Quincy, and many other prominent roads.

LARGE orders for freight cars seem to be the rule just now, and the car shops all over the country are busy. The fact is, that on many of the roads the equipment has been allowed to run down to a very low point, making extensive renewals an absolute necessity.

THE Pullman Car Works, Pullman, Ill., have an order for 25 passenger cars for the Central Railroad of New Jersey.

THE Rome Iron Company has been organized to build a charcoal furnace and a car-wheel foundry at Rome, Ga. The capital stock is $300,000.

Bridges.

THE Keystone Bridge Company, Pittsburgh, has the contract for the new bridge over the Missouri River at Kansas City for the Kansas City Terminal Railroad.

THE bill introduced in Congress to authorize the bridging of the Hudson River at New York names as incorporators Jordan L. Mott, Thomas F. Ryan, Charles J. Canda, New York; Edward F. C. Young, Jersey City; G. A. Hobart, Paterson, N. J.; W. A. Roebling, F. C. Roebling, Trenton, N. J.; Samuel Rea, William F. Shunk, Philadelphia; Philip E. Chapin, Washington; John K. McLanahan, Hollidaysburg, Pa.; James Andrews, Allegheny, Pa.; John H. Miller, Gustav Lindenthal, Pittsburgh; Henry Flad, St. Louis. The plans, as prepared by Mr. Lindenthal, have been already described; they are for a suspension bridge, with a central span of 2,850 ft. and two side spans of 1,500 ft. each, the roadway to be 155 ft. above high water. The cost of the bridge, not including approaches, is estimated at $16,000,000. It will be fitted to carry 10 tracks.

THE Baltimore & Ohio Railroad is asking for bids for a double-track bridge, to replace the present Bollman truss bridge across the Potomac River at Harper's Ferry.

THE Edge Moor Bridge Works have the contract for the Delaware River Bridge at Phillipsburg for the Central Railroad of New Jersey. The bridge is 1,000 ft. in length, and will consist of three 200-ft. spans, part of the old bridge, and some trestle work.

THE contract for the iron work of the warehouses under the approaches of the Brooklyn Bridge has been let to the Phœnix Bridge Company.

THE Passaic Rolling Mills, Paterson, N. J., recently completed two 18-ton open-hearth furnaces, and are prepared to roll steel angles and shapes. A trial cast was made December 19, which was entirely successful.

THE Pottsville Iron & Steel Company is pushing to completion the new bridge shop. The company is already in the market for girder work.

THE contract for the Alabama River Bridge, for the Alabama Midland Railroad, has been let to the Phœnix Bridge Company. The bridge consists of one 300-ft. draw span and two approach spans of 250 ft. each.

THE King Iron Bridge & Manufacturing Company, Cleveland, O., has the contract for an iron arched bridge for the city of Baltimore.

THE Central Railroad of New Jersey is asking for bids on a four-track bridge of 130-ft. span, to be erected one mile west of Jersey City.

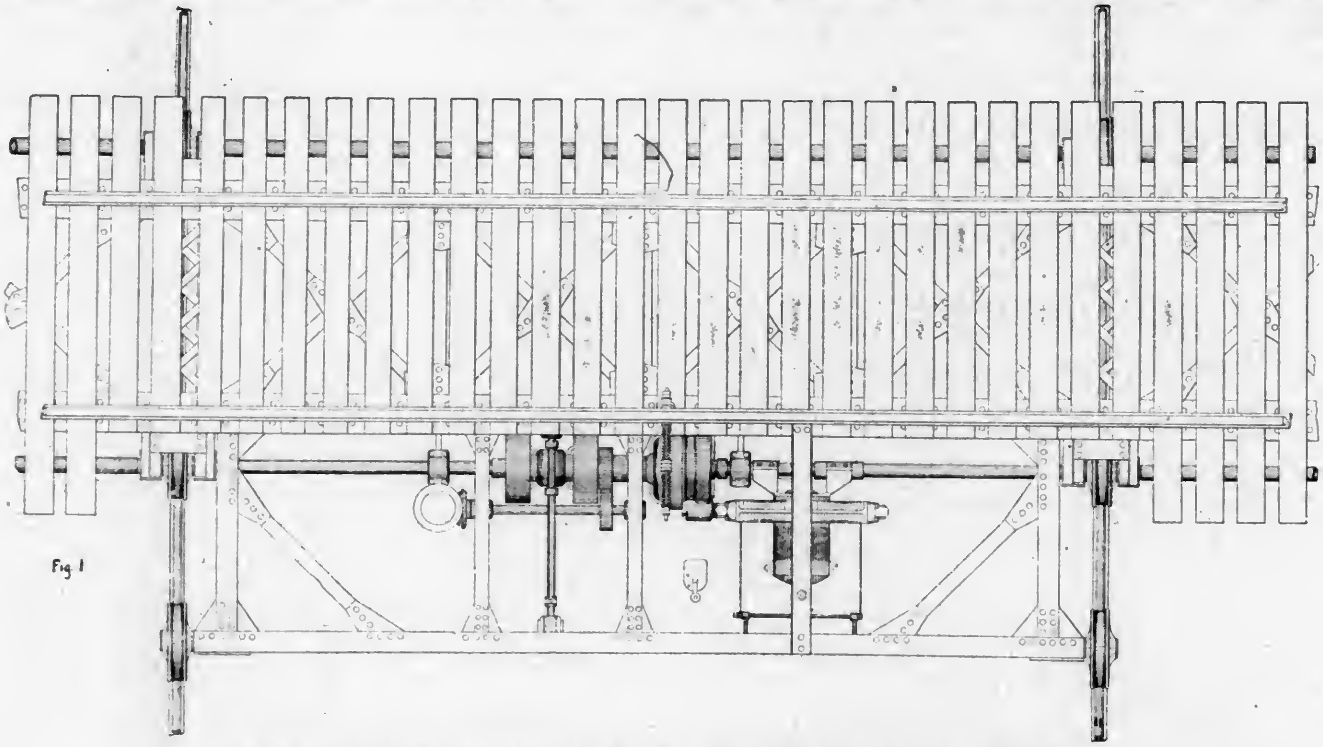
THE New York Central & Hudson River Railroad recently placed orders for two small drawbridges with the Elmira Bridge shops.

An Electric Transfer Table.

THE accompanying illustrations show a transfer table operated by an electric motor, which has lately been put in at the repair shops of the Fitchburg Railroad, in Fitchburg, Mass. The table is 70 ft. in length by 10 ft. wide, and runs on four rails in the pit between the shops; it is used to move cars to and from the tracks in the two parallel shops, each 500 ft. long,

these tracks being 48 in number. It is built in the ordinary way, carrying a single track.

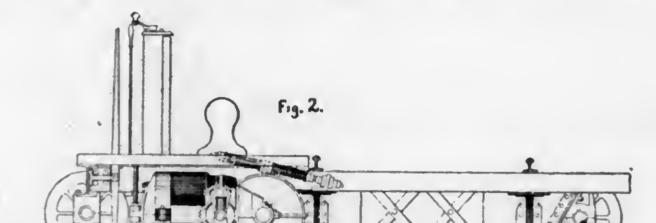
The distinction from an ordinary transfer table here is in the method of operating it, which is by an electric motor on the system of the Union Electric Car Company of Boston. This motor is shown in the drawings, fig. 1 being a plan of that portion of the table where the motor is situated; fig. 2 a side view,



ELECTRIC TRANSFER-TABLE AT FITCHBURG RAILROAD SHOPS.

and fig. 3 a section on a larger scale through the case in which the gearing attached to the motor is inclosed.

The motor is attached to the front axle of the table, and is suspended by bolts from the channel bars forming a portion of the frame, as shown. The gearing is enclosed in a circular case to prevent the entrance of dirt, etc. The last gear in the series is clamped to a long sleeve, which rotates freely on the axle of the table and passes out of the case to clutches, one of which is keyed to the axle, while the other revolves freely on a sleeve. When the clutch collar is thrown in the proper direction, the sleeve is clutched to the shaft, and the motor propels the table. By throwing the collar in the opposite direction the sleeve is connected with the other clutch, which through a proper set of gearing operates the capstan, which is used to haul cars on and off the table. The machinery for shifting the communicator

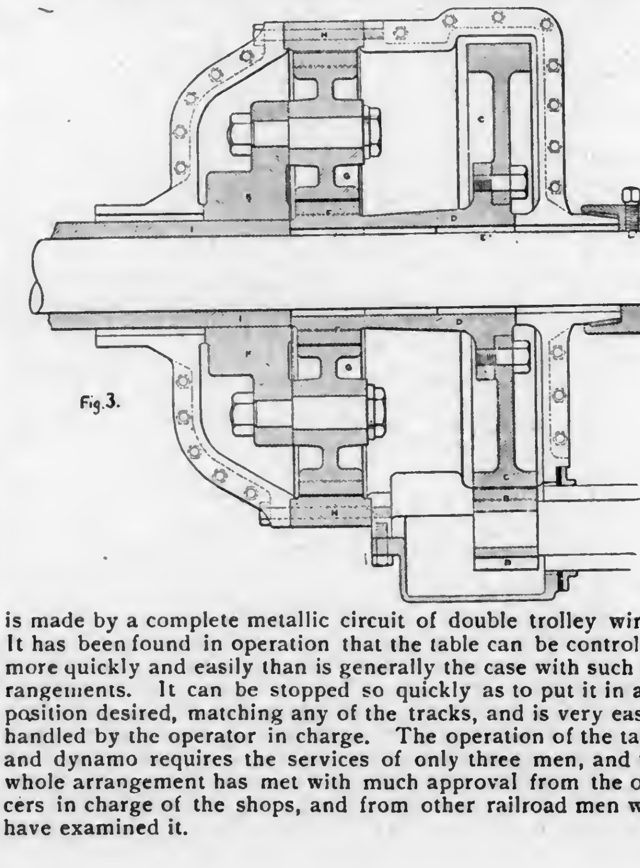


brushes reverses the direction of rotation, and consequently the motion of the table, all the movements of which are controlled by a simple electric switch. Two extra bearings are placed upon the shaft to support the extra weight of the motor and gearing. The extension of the table for supporting and enclosing the motor is floored and housed over to protect the operator and apparatus from the weather. The motor can be reached through trap doors in this floor when desired.

Fig. 3, as noted above, shows a horizontal section through the gear case. In this cut *A* is the axle of the car which rotates free of any attachments in the case. The pinion *B* is keyed to the armature shaft, and engages the large gear *C*, which is mounted on the sleeve *D*; this sleeve turns on the shaft *A* on bushings *E E*, and at *F* connects with a pinion which engages the gear-wheels *G G*. These latter are intermediate between the pinion *F* and the internal gear-wheel *H*, enclosing the whole. The gears *G G* are fixed by stud-pins to the spider *K*, which is clamped to the sleeve *I*, and the latter passes through the case to the clutches shown in fig. 1.

The rotation of the pinion *F* causes the gears *G G* to travel around on the internal gear *H*, carrying with them the spider and its attached sleeve. The case is partially filled with a light oil which, when the gears revolve, is carried into every part of the interior of the case, and through proper passages reaches all the bearing surface. The large gears *C C* act as a pump, throwing a constant stream of oil on the motor pinion. This arrangement has been found to work very well, keeping the pinion constantly lubricated and preventing wear in spite of the rapidity of the motion.

The electricity for the motor is furnished from the dynamo which operates the electric lights of the shops. The connection



is made by a complete metallic circuit of double trolley wires. It has been found in operation that the table can be controlled more quickly and easily than is generally the case with such arrangements. It can be stopped so quickly as to put it in any position desired, matching any of the tracks, and is very easily handled by the operator in charge. The operation of the table and dynamo requires the services of only three men, and the whole arrangement has met with much approval from the officers in charge of the shops, and from other railroad men who have examined it.

The table and motor were designed by the Union Electric Car Company, and the illustrations are from drawings made by that Company.

Lighting Cars.

THE horrible accident which occurred on the Cincinnati, Hamilton & Dayton Railroad on January 17 reiterates with terrible emphasis the necessity for taking every precaution to prevent the repetition of such calamities. In this case, as in other instances of a similar kind, passengers were fastened in the wreck and burned to death in the presence of the onlookers, who could give no aid, and were helpless to prevent the awful agony which was greater than that of a martyr burned at the stake.

Heating by steam is making progress, but not as rapidly as circumstances demand, as is shown by this and other accidents; but the influence of State legislation and the Railroad Commissioners is now exerted in favor of its general introduction; although it will probably require the sacrifice of more lives, the stimulus of public indignation, and the strong hand of the law to overcome the lethargy of railroad directors and managers.

The subject of lighting cars has received less attention than heating, because the danger is less apparent. That carrying several gallons of very combustible oil, which is distributed in a car where, in case of an accident, it will be most effectually scattered, is a source of great danger, is very obvious. Besides this, if cars are ineffectually lighted, it imposes upon passengers from three to six dismal hours in which reading is impossible, and they are driven to reflect on their misfortunes and shortcomings, which leads to a low state of dejection and melancholy.

Railroad companies have not the excuse any longer that there is no satisfactory system of lighting cars excepting oil lamps. It is not our purpose to sit in judgment on the relative merits of the various systems now in use; but it can be said confidently that if there is none better, the Pintsch system is giving satisfactory results. It has been mentioned in these pages before, that an unwillingness to profit by the experience of others appears to be a national defect in the American character. Precedents are, however, useful guides. In the matter under consideration we have the fact before us that the Pintsch system of lighting cars is used extensively in England, Germany, France, Holland, Italy, Austria, Russia, Sweden, Denmark, Switzerland, Egypt, Brazil, and also in this country, on nearly, or quite, 30,000 cars. The use is not recent either, but has extended over a sufficiently long period to fully test the efficiency of the system. The rate of increase also shows that its use has been sufficiently satisfactory to lead to a rapid extension, as from 1883 to 1886 about 23,000 cars were equipped with it. In this country it is used on the New York, Lake Erie & Western Railroad and ferry-boats; the West Shore Road and boats; New York, Providence & Boston; Chicago & Atlantic; New York Central & Hudson River; Boston & Albany; Old Colony; New York & New England; Louisville, New Albany & Chicago; Cincinnati, Hamilton & Dayton roads; Pullman's Palace Car Company; Wagner Parlor Car Company; Providence & Stonington Steamship Company's boats; Hoboken Land & Improvement Company's boats; and the New Jersey Central and the Cleveland, Cincinnati, Chicago & St. Louis Railroads are erecting works for future use. In all over 1,000 cars in this country are lighted by this system.

The following description will give a general idea of its essential features:

PROCESS OF MANUFACTURE.

The material used for the manufacture of Pintsch gas is crude or refined petroleum, or the residual products of coal oil distillation. Crude petroleum is the cheapest material, and the one generally employed. The oil is passed through suitably arranged iron retorts kept at a high temperature by a coal fire below them. The furnace is of such design that the retorts are evenly heated from end to end, and are kept at such a temperature as to thoroughly convert into gas the oil, which is fed into them through specially-arranged pipes and graduating cocks. The product is a rich and permanent gas, and of the highest illuminating power known in the art. From the retorts it passes through water seals, and is led by a pipe to the condenser, where it is cooled. In this it deposits the vapor of water, tar, etc., mechanically carried over with the gas. From the condenser it passes through a washer, which further purifies it, and then through lime purifiers, which effect the removal of all traces of impurities which may still remain. It is then measured and passes to the gas-holders, from which it is drawn by the compressor and stored under any desired degree of compression in the tanks, from which pipes lead wherever it is convenient to convey it for use. The process is a simple one, very direct and economical. A plant capable of making all the gas required for 500 cars is contained in a building 26 ft. 4 in. by 38 ft. 6 in., one story in height. The storage tanks may be placed where it is most convenient, and are larger or smaller in proportion to the requirements of the service.

DISTRIBUTION TO CARS.

From the storage tanks pipes are laid to such points in the yards as are most convenient for charging the reservoirs of the cars. These pipes are provided with suitable valves, and by means of special hose, with quick-acting couplings, the gas is transferred to the tanks under the cars. These tanks are filled to a pressure of 150 lbs. A very much higher compression can be obtained if desired, but experience has shown that it is not good practice to compress the gas more than is needed. The tanks are filled very quickly, and no time is lost on this account, even when the filling is done at an intermediate station. A stop long enough to supply the engine with water or coal, or to change locomotives, is sufficient for filling the tanks.

PRESSURE REGULATION.

At the pressures at which the gas is charged into the tanks, its combustion in lamps is impossible without perfect regulation. This pressure, it should be remembered, constantly though very slowly diminishes as the gas is burned, and the conditions of satisfactory lighting demand that while any gas remains in the tank in excess of atmospheric pressure, it shall give as good a light as when the tank is charged to its full capacity. The regulator is placed under the car, and, without attention, and under all conditions of service, maintains a constant pressure of gas on the pipes leading to the lamps, whether one or all are burning, or none are in use. It is entirely automatic, and when adjusted and put in position needs no further attention, and the cover of the iron box containing it need never be removed.

THE LAMPS.

The lamps manufactured for railroad service are of great variety, and are adapted to every kind of coach. Those for passenger cars are all made upon one principle. They are suspended from the ceiling, and one of the suspending arms furnishes the gas-way. Two or four burners are used, as desired. These are enclosed in glass globes, which perfectly shield them from disturbing air currents, and place them wholly beyond curious or malicious interference. Above the flames is a white porcelain reflector, which greatly aids in the distribution of the light rays, and very much increases the brilliancy of the illumination. These lamps are shadowless; and, as travelers by the lines on which they are employed have observed, four lamps in a passenger coach of full size, give an illumination which permits the passenger to read easily and comfortably.

After the works and the machinery are erected, it is said that this system is cheaper than lighting by oil; it is certainly much cleaner and safer, and, as remarked in the early part of this article, we are not prepared to sit in judgment on all the methods of lighting now before the public, but it may be said confidently, that if no better system can be found than the Pintsch, railroad companies should adopt it in preference to oil, if for no other reason, to prevent such dreadful accidents as the one already referred to and others equally horrible.

Manufacturing Notes.

THE Brown & Sharpe Manufacturing Company, Providence, R. I., received an award of the highest class for its exhibit of machines and tools at Paris.

THE name of the Bucyrus Foundry & Manufacturing Company at Bucyrus, O., has been changed, and it will hereafter be known as the Bucyrus Steam Shovel & Dredge Company. This change has been made in order better to describe the business of the Company, which is principally in the manufacture of steam shovels, dredges, wrecking cars, and similar work. There is no change in the management, but the capital stock will be increased to $150,000, in order to provide for an increase in manufacturing facilities which is necessary.

THE gold medal of the Paris Universal Exposition of 1889 was awarded to Valentine & Company for their coach and railroad varnishes. In addition to the exhibit made by the Company, there were in the Exposition a large number of coaches and carriages built in different countries on which the Valentine varnishes were used, thus giving excellent opportunity to show its quality.

OBITUARY.

Horatio Allen, who died at his residence in South Orange, N. J., January 1, aged 88 years, was for many years prominent as a civil and mechanical engineer. In early life he was connected with the Delaware & Hudson Canal Company and the South Carolina Railroad, and took a prominent part in the introduction of locomotives on American railroads. Later he was for many years the head of the Novelty Iron Works in New York, where the machinery of some of the best-known American steamships was built. Mr. Allen retired from active work some years ago, but continued to take a lively interest in engineering matters. A more extended notice of his work will be found on another page.

William Stroudley, who died in Paris, December 20, aged 56 years, was born in Oxford, England, and learned the machinist's trade in Birmingham. In 1861 he was made Superintendent of the shops of the Edinburgh & Glasgow Railway; in 1865 Locomotive Superintendent of the Highland Railway, and in 1870 Locomotive Superintendent of the London, Brighton & South Coast Railway. This last position he held until his death, and in it made a great reputation as a mechanical engineer, the locomotives he designed being considered as among the best of the English type. In addition to his purely railroad work, he also had charge of the company's steamers running across the English Channel, and designed the engines of a number of those boats. He was noted among English engineers for his careful attention to details, his keen sense of mechanical fitness, and his excellent judgment.

Samuel Keefer died at his residence in Brockville, Ont., January 7, aged 79 years. He was born in Thorold, Ont., and commenced work in the engineering corps of the Welland Canal in 1827. In 1839 he was made Secretary of the Canadian Board of Works, and in 1841 Chief Engineer. In 1853 he was appointed Engineer of the Grand Trunk Railway, and held that position for four years. From 1857 to 1859 he was Inspector of Railroads, and from the latter year to 1864 Deputy Commissioner of Public Works for the old province of Upper Canada. He had charge of the building of the Suspension Bridge at Niagara Falls, and some time later he surveyed the line of the Baie Verte Canal, and was afterward Secretary of the Canadian Canal Commission. For many years he was connected with almost every important work carried on in Canada. For some years past Mr. Keefer had retired from active work, his only recent public appearance being as a Commissioner in the Canadian Pacific inquiry a year ago. He was a brother of Mr. Thomas Keefer, who was recently President of the American Society of Civil Engineers.

Dr. Charles A. Ashburner died at his home in Pittsburgh, December 24, aged 35 years. He was born in Philadelphia, graduated at the University of Pennsylvania, and at once commenced work as an engineer, being employed on the Government surveys of the Delaware River and in the lighthouse surveys. In 1874 he was appointed Assistant to Professor J. P. Leslie in the Geological Survey of Pennsylvania, in which position he was actively employed until 1880. In that year he was appointed Geologist in charge of the surveys of the anthracite coal fields, and his original methods of surveying and measuring those coal measures attracted much attention. In 1885 he was appointed Geologist in charge of all the field and office work of the survey. Some time ago he removed to Pittsburgh, having been appointed Scientist for the Westinghouse Company and the Philadelphia Gas Company. Although still a young man, he was considered a high authority in geology, and especially in all questions relating to coal and oil. Only a few weeks before his death he had agreed to superintend the collection of statistics on coal and natural gas for the Census of 1890, and his services as consulting engineer were in much demand by mine operators.

PERSONALS.

J. P. Williams has been appointed a member of the Minnesota Railroad Commission.

G. A. Bell has been appointed General Superintendent of the Troy Iron & Steel Company at Troy, N. Y.

J. A. L Waddell, C.E., is Chief Engineer of the new bridge over the Missouri River at Sioux City, Ia.

John W. Hill, C.E., of Cincinnati, has been appointed Chief of Engineers on the staff of Governor Campbell, of Ohio.

Charles Macdonald has been elected President of the Engineers' Club of New York.

Arthur G. Wells has been appointed General Superintendent of the Ohio, Indiana & Western Railroad.

W. B. Chadwick has been appointed Superintendent of Water-Works at Chester, Pa.

Colonel T. M. R. Talcott has resigned his position as Vice-President of the Richmond & Danville Railroad Company.

Professor J. W. Spencer has been appointed State Geologist of Georgia and will have charge of the general survey of the State.

A. J. Burt has been appointed Assistant Auditor of the Michigan Central Railroad, succeeding F. Braisted, who has resigned.

I. G. Rawn has been appointed Superintendent of the Richmond, the James River, and the Peninsula divisions of the Chesapeake & Ohio Railroad.

Charles Wood has been appointed Chief Engineer of the Cincinnati, Hamilton & Dayton Railroad. He has been Assistant Engineer for several years.

Francis B. Clarke has resigned the position of General Traffic Manager of the Chicago, St. Paul, Minneapolis & Omaha Railroad, to devote his time to other interests.

A. A. Robinson, heretofore Second Vice-President and Chief Engineer of the Atchison, Topeka & Santa Fé Railroad, has been appointed General Manager of the Company's lines.

H. M. Perry has been appointed Superintendent of the works of the United States Rolling Stock Company at Hegewisch, Ill., in place of F. W. Wilder, who has resigned.

Frank Lawlor, late Division Engineer of the Chicago, Burlington & Quincy Railroad, has accepted a position in the Construction Department of the Western Railroad of Uruguay.

Joseph Ramsay, Jr., late Chief Engineer of the Cincinnati, Hamilton & Dayton Railroad, is now Assistant to the President of the Cleveland, Cincinnati, Chicago & St. Louis Railroad.

L. B. McKee, C.E., has been appointed Engineer in charge of the construction of the new coal piers and storage trestles of the New York, Ontario & Western Railroad at Weehawken and Oswego.

W. W. Peabody has resigned the position of General Superintendent of the Trans-Ohio Lines of the Baltimore & Ohio, to become Vice-President of the Baltimore & Ohio Southwestern Railroad.

Richard Carroll has been appointed General Manager of the Cincinnati, New Orleans & Texas Pacific Railroad in place of John C. Gault, who has resigned. Mr. Carroll has been General Superintendent for a number of years.

John Bogart, State Engineer of New York and Secretary of the American Society of Civil Engineers, has declined the office of Commissioner of Street Cleaning of New York City, which was offered him recently by Mayor Grant.

John Headden has been appointed Superintendent of the King Locomotive & Car Works at Bordentown, N. J. Mr. Headden was for a number of years Master Mechanic of the old New Jersey Railroad, and was afterward with the Rogers Locomotive Works for a long time.

Horace Loomis has been appointed Commissioner of Street Cleaning of New York City by the Mayor. He is a civil engineer by profession, and for some ten years was employed in some railroad work on the New York, Lake Erie & Western and the New York, Susquehanna & Western roads. From 1875 until the present time he has been employed on city work, first in the Croton Aqueduct Bureau, afterward as Chief Engineer of Pavements, and more recently as Engineer in charge of Sewers, an experience which ought to make him a capable officer in his new position. Mr. Loomis is a graduate of the Rensselaer Polytechnic Institute, and a member of the American Society of Civil Engineers.

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers.—The 37th annual meeting began in New York, January 15, President Becker in the Chair. The annual report of the Directors showed a total membership of 1,335. The Treasurer's report showed receipts for the year of $39,800 and a balance on hand of $10,924.

The Committee appointed last year to revise the constitution and by laws submitted a report. This report has already been published and considered.

It was announced that the Norman medal had been awarded to Mr. Theodore Cooper, for his paper on American Railroad Bridges. The Rowland prize had been awarded to James D. Schuyler, for his paper on the Construction of the Sweetwater Dam.

The tellers announced the result of the election for officers for the ensuing year, as follows: President, William P. Shinn; Vice-Presidents, A. Fteley and Mendes Cohen; Secretary, John Bogart; Treasurer, George S. Greene, Jr.; Directors, Charles B. Brush, Theodore Voorhees, Robert Van Buren, William Ludlow and William G. Curtis.

At the evening session Mr. Charles Macdonald delivered an address on the Construction of the Hawkesbury River Bridge in Australia, of which he had charge. This bridge, it will be remembered, had seven spans of 416 ft. each, and it was necessary in preparing the foundations for the piers, to go down from 100 to 160 ft. below the surface of the water. The address was illustrated by photographs and views.

January 16, the members of the Society visited the Government Works at Willett's Point, and afterward the Brooklyn Navy Yard. In the evening they attended a reception given them by the Engineers' Club.

Other business transacted at the meeting consisted in several reports presented by Committees. The Committee on the Failure of the South Fork Dam stated that its report was prepared, but recommended that its conclusions be not made public at present, but the report be retained subject to the call of the Society. The reason given is that suits for damages are now pending in the courts of Pennsylvania, and that it is not thought proper to impress any opinions which would influence those suits.

The Committee on Uniform Standard Time reported progress, and submitted a memorial to Congress, asking for such action as may be necessary to legalize the 24-hour system.

The Committee on Impurities in Water Supply reported recommending the collection of information on this subject, and suggesting the employment of an expert.

The Committee on Methods of Testing Structural Material was announced as follows: G. Bouscaren, W. H. Burr, R. W. Hunt, J. G. Dagron, Percival Roberts, H. G. Morse, and H. B. Seaman.

The Committee upon Standard Rail Sections was also announced, but a discussion sprang up upon this matter, and it was finally decided to refer for letter-ballot a resolution discharging this Committee. A motion for the appointment of a Committee on Units for Measurement was also referred to letter-ballot.

Boston Society of Civil Engineers.—At the regular meeting, December 18, Benjamin W. Guppy and William J. Watkins were elected members. The Committee to consider the advisability of urging upon the Legislature the immediate printing of the new map of the State, submitted a report favoring such action. The Society authorized the same Committee to appear in its behalf before the Legislature, and urge the immediate printing of a small edition at least. The Committee on Revision of the Constitution, submitted a draft of a new Constitution and By-laws of the Society which was unanimously passed.

Mr. William E. McClintock, City Engineer of Chelsea, read a paper describing three methods of heating and ventilating school-buildings, which had been used in that city. Mr. Theodore P. Perkins followed with an account of methods of heating and ventilating which had been used in Lynn, and Professor S H. Woodbridge, of the Institute of Technology, described a system well suited for small school-houses. A general discussion upon heating and ventilation of buildings closed the meeting.

New England Water-Works Association.—At the adjourned meeting in Boston, January 8, the following-named gentlemen were elected Resident Active Members: Lewis M. Bancroft, Reading, Mass.; Walter Hale, Westfield, Conn.; Arthur F. Salmon, Lowell, Mass.; F. P. Webster, Lake Village, N. H.; Philip J. Doherty, Boston, Mass.; Charles E. Drake, New Bedford, Mass.; L. R. Forbes, Brookline, Mass. Associate Member: Wilmer Reed, Burlington, N. J.

Mr. W. H. Richards read a paper on Thickness of Cast-Iron Pipes and Special Castings, his paper having special reference to the extension of the water-works at New London, Conn. This was followed by a general discussion, in which it was stated that the general tendency was to make pipes too light.

The Recent Boston Fire and the amount of water used and wasted was discussed. Mr. Brackett opened, estimating the consumption of water at 24,000,000 gallons, and he was followed by Messrs. Tidd, Winslow, Walker, and others.

Leaks in Cement-lined Iron Pipe were discussed by a number of members present.

Worcester Society of Civil Engineers.—The annual meeting was held January 3. Officers were elected for the year, as follows: President, J. H. Shedd; Secretary, M. A. Boyden; Treasurer, F. L. Allen; Executive Committee, E. K. Hill, A. W. Woods, and W. E. Hassen.

Engineers' Club of Philadelphia.—At the regular meeting, December 21, the Secretary presented, for Professor W. H. Burr, some notes on the Application of Electric Motors to Elevated Railroads; also, for Mr. G. W. Chance, a paper on Right of Way.

Mr. James Christie presented Notes on Riveted Joints. He confined his remarks entirely to single-riveted lap joints as commonly used in the circular seams of steam boilers, and gave a history of a series of experiments, an analysis of which shows, he states, that an increase of efficiency was found to be due to the clamping force exercised by the rivet heads, with possibly a slight gain due to better bearing service, and that no instance was known of this binding of the joint, due to increase of rivet area, failing to show an enlarged resistance to rupture.

Mr. Arthur Marichal presented, for himself and Mr. John C. Trautwine, Jr., a translation from the French of a pamphlet published by the prominent hydraulician, M. Bazin, giving the results of very extensive experiments on the Flow of Water over Weirs.

The Secretary presented, for Mr. Walter S. Church, Some Suggestions About Testing the Strength and Tightness, and Rating the Carrying Capacity of the New Croton Aqueduct, N. Y. The object of this paper is to show the advantages and safety of delivering the much larger quantity of water through the Croton Aqueduct, which can be delivered if it is placed under pressure, than by gravity alone; that, at a reasonable outlay, its carrying capacity can be doubled, which would, he considers, ultimately double the commercial value of this great aqueduct.

Mr. Edward Hurst Brown presented a paper upon the Æsthetic Value of Engineering Constructions.

There was considerable verbal discussion of several of the above-mentioned papers.

THE annual meeting was held in Philadelphia, January 11. The retiring President, Mr. William Sellers, delivered his annual address, which was devoted to the proper limitations of manner training schools and the character of instruction which should be given therein, and also to good highways and the proper method of obtaining them.

The Secretary and Treasurer presented his report, showing the Club to be in good financial condition. The membership includes two honorary, 481 active, and 16 associate members.

The tellers reported the following officers elected for 1890: President, Professor H. W. Spangler; Vice-President, Wilfred Lewis; Secretary and Treasurer, Howard Murphy; Directors, John T. Boyd, George Burnham, Jr., E. V. D'Invilliers, Henry G. Morris, and S. M. Prevost.

The Committee on Revision of Rules presented a report with regard to the election of members, which was referred to the Board of Directors.

The Secretary presented, for Professor L. M. Haupt, Secretary of the Committee on Better Roads of the University of Pennsylvania, the conditions of competition for the prizes of $400, $200, and $100 for the three best papers on Road-Making and Maintenance. A full descriptive circular can be had on application by mail to Professor L. M. Haupt, at the University of Pennsylvania, Philadelphia.

A Committee was appointed to arrange for a Club reception. The new President then took his seat and made a short address.

Engineers' Society of Western Pennsylvania.—At the regular meeting in Pittsburgh, November 19, W. G. Bell, W. A. Cornelius, C. H. W. Ruhe and J. J. E. Wolfle were elected

members. A committee to collect facts and data of interest to engineers on the Johnstown disaster was appointed, the members being A. Dempster, T. P. Roberts, A. Snyder, and Charles Davis. A committee to nominate officers was appointed, the members being William Thaw, Jr., H. D. Hubbard, and F. C. Phillips.

Mr. Arthur Kirk read a paper on the Use of Dynamite in Breaking up the Jam at Johnstown, which called out a general discussion.

Engineers' Club of Cincinnati.—The second annual meeting of the Club was held on the evening of December 19, with 29 members present.

Two applications for membership were received and four new members were elected, making a total membership of 90 at that date.

The following officers were elected to serve during the ensuing year: President, G. B. Nicholson; Vice-President, R. L. Read; Directors, K. E. Hilgard, L. W. Mathewson and Ward Baldwin; Secretary and Treasurer, J. F. Wilson.

The Treasurer submitted his report of receipts and expenditures, and the retiring President read a very interesting address on the progress of engineering during the past year. A bountiful supper supplemented the evening's entertainment.

Western Society of Engineers.—At the annual meeting in Chicago, January 8, the following officers were elected for the ensuing year: President, L. E. Cooley; Vice-Presidents, Robert Shaler and William R. Northway; Secretary and Treasurer, John W. Weston; Trustee, Benezette Williams.

Civil Engineers' Club of Cleveland.—At the regular meeting in Cleveland, O., January 14, Sydney H. Short, F. E. Bright, and L. E. Holden were elected members.

Mr. A. Mordecai read a paper on the Harbor Facilities of Cleveland, comparing especially its facilities for handling coal and ore with that at other lake ports.

Mr. Edward Lindsay exhibited a model of a device of his own for unloading cars, which consists essentially in running the car into a cylinder whose center is a little below the car floor. The car is then held in a suitable manner and the cylinder revolved, so as to place the car upside down, emptying its contents into carts below.

Mr. J. H. Sargent read a paper on a Belt Line Railroad, advocating the extension of the breakwater, the building of a series of slips, and the formation of a system of docks giving a large increase in the lake front, with a belt line connecting these docks with all the principal railroads entering Cleveland.

Engineers' Club of St. Louis.—At the regular meeting in St. Louis, December 18, the Executive Committee announced the result of the ballot for officers for 1890 as follows: President, F. E. Nipher; Vice-President, George Burnet; Secretary, William H. Bryan; Treasurer, Charles W. Melcher; Directors, E. D. Meier and S. Bent Russell; Librarian and Manager, J. B. Johnson; Manager, J. A. Seddon.

Addresses were made by the new and the retiring presidents.

B. H. Colby was elected a member. The receipt of several valuable books and photographs for the library was announced. A communication in relation to the Eads monument was referred to the special committee on that subject.

Professor J. B. Johnson, Chairman, presented a report for the Committee on National Public Works; ordered that the report be accepted, and the committee discharged. Professor Johnson also announced that the Board of Managers had, at its recent meeting, decided to change the place of publication of the *Journal* to Chicago, about April, 1890, and that an address was being prepared on the subject of a national organization of engineers.

Mr. Nils Johnson showed the club a pump valve, which had been operated under a pressure of 550 lbs. for 15 minutes with ordinary hydrant water.

At the regular meeting in St. Louis, January 8, the Executive Committee submitted a programme of meetings and papers for the year, including a number of papers by well known engineers on important subjects.

Mr. B. F. Crow read a paper on a Method for Definite Location of Gauge Line on Car-Wheels. He discussed the matter principally with reference to street railroad practice, showing the present lack of uniformity. The paper was discussed by members present.

Professor J. B. Johnson read a paper on Deflection of Framed Structures, to which he had added a discussion of the distribution of stresses over redundant members. This paper was generally discussed, several members calling attention to the importance of the question, and to the fact that too little attention is generally paid to it by engineers.

Civil Engineers' Society of St. Paul.—At the regular meeting in St. Paul, Minn., December 2, G. L. Cresson was elected a member.

The paper of the evening—on Methods of Taking Topography over Extended Areas—was read by Mr. F. Freyhold.

Engineers' Club of Kansas City.—At the annual meeting, December 4, the Secretary reported that 12 meetings of the Club had been held during the year. There were now 83 members in all. Candidates for officers for 1890 were named. The Secretary also reported that 16 papers have been presented during the year, besides the general discussion of Sewerage at the November meeting.

The Annual Banquet and a Field Meeting in September were notably pleasant features of the year.

The Committees on Bridge Reform, National Public Works, Transfer of Members and Affiliation of Engineering Societies have done considerable work, but in each case developments from outside are awaited before further action is taken.

A Committee on Cements and Mortars has been appointed, from which we shall no doubt receive valuable information in the future.

At the regular meeting, December 2, Thomas Callahan was chosen an associate member.

The subject of Sewer Ventilation was discussed by Messrs. G. W. Pearsons, H. H. Filley, F. E. Sickels, and K. Allen.

Mr. F. E. Sickels then read the paper of the evening, on Snow Plows, illustrated by models from actual practice and drawings.

Civil Engineers' Association of Kansas.—The annual meeting was held in Wichita, Kan., December 18. The following officers were elected for the ensuing year: President, Professor W. A. Crusinberry; Vice-Presidents, O. Mulvey and R. W. Luttrell; Secretary, J. C. Herring; Librarian, H. H. Jackman; Treasurer, W. R. Kesler.

Meetings are held on the evening of the second Wednesday in each month, when papers of general interest to the profession are read and discussed. Visiting engineers are always welcome at the meetings, and at the Library of the Association.

Iowa Civil Engineers' and Surveyors' Society.—The second annual meeting was held in the City Hall, at Des Moines, Ia., beginning December 27, with a good attendance of members. The report of the Secretary, Mr. Seth Dean, showed an increase of new members during the year and no losses, there being at present 40 members on the list. Arrangements have been made to exchange proceedings with the State societies of Ohio, Indiana, Illinois, Michigan, Connecticut, and Arkansas, and with the surveyors' associations of Ontario and of the Dominion of Canada. Treasurer Macdonald's report showed a small balance in the treasury.

President Gilchrist then delivered his annual address, which contained many valuable suggestions for the welfare of the Society.

A paper on the subject of Street Pavements was read by Mr. Steyh, City Engineer of Burlington, who discussed the merits and defects of the various kinds of pavement, and recommended for most cities a trial of brick, as being both cheap and durable, and also free from noise and easily cleaned. This paper was followed by an extended discussion of the question, covering not only the paving question but the manufacture of brick and the necessary qualities of clay required for that purpose.

After adjournment the members by invitation inspected the Des Moines Street Railroad and its plant.

On the second day, the report of the Executive Committee was presented, favoring the incorporation of the Society and the commencement of a library. The Committee was instructed to procure the necessary act of incorporation.

Mr. R. G. Brown read a paper on Race Tracks, giving an explanation of the principles involved, both practical and mathematical, in laying out the several forms of track in general use.

Secretary Dean read a paper on the Law of Accretion, from which it appears that the law is not by any means uniform in different States on this question. This paper was generally discussed.

Mr. M. Tschirgi, City Engineer of Dubuque, read a paper on the subject of Water Works for small towns.

Officers for the ensuing year were then elected as follows: President, E. M. Gilchrist, Keokuk; Vice-President, M. Tschirgi, Dubuque; Secretary, Seth Dean, Glenwood; Treasurer, F. A. Macdonald, Burlington; Directors, M. R. Laird, Charles Bennett, Des Moines.

The members then inspected the works of the Des Moines Tile Company, seeing in operation the manufacture of drain-tile and paving-brick.

After the excursion the usual resolutions of thanks, etc., were passed, and the Convention adjourned.

New England Railroad Club.—At the regular meeting in Boston, January 8, notes on European Travel and Railroad Practice in Europe were submitted by Messrs. John Coghlan, Firth, and A. J. Pitkin; these gentlemen describing what they had seen in England, France, Germany, Russia, and other countries, and comparing practices there with our methods at home.

Western Railway Club.—At the regular meeting in Chicago, January 21, the first subject for discussion was the Ventilation of Cars, and on this an elaborate paper by Mr. W. G. Creamer was read and afterward discussed.

The second subject was the Efficiency of the Link as Compared with other Valve Motions.

Montana Society of Civil Engineers.—At the regular meeting in Helena, Mont., December 21, a Committee was appointed to make arrangements for the annual meeting. Officers were nominated for the ensuing year.

A SPECIAL meeting was held in Helena, January 11, to take action upon the death of the President of the Society, General B. H. Green. A Committee composed of Messrs. Keerl, De Lacy, and Haven was appointed to draft a memorial and have the same printed in pamphlet form, with a likeness of the late President. It was resolved to dispense with the excursion and dinner arranged for the annual meeting and to confine that meeting strictly to the transaction of business.

Northwest Railroad Club.—The first annual meeting was held in St. Paul, January 4. The Secretary reported a total of 40 members. The President made a short address, speaking of the progress made by the Club during the year.

The following honorary members were chosen: W. A. Scott, T. E. Clarke, C. W. Case, and H. A. Towne. The old officers were elected, as follows: President, W. T. Small; Vice-Presidents, W. T. Reed, G. F. Wilson; Secretary, H. P. Robinson; Treasurer, H. L. Preston.

It was decided to appoint as subject of discussion for the next meeting the circular of the Master Mechanics' Committee on Axles for Heavy Tenders.

NOTES AND NEWS.

A Pneumatic Street Railroad.—A street railroad about 1½ miles long, on an entirely new principle, is being constructed in Washington, by the Judson Pneumatic Railway Company of New York. In this system, power is to be transmitted by compressed air from a central station to a series of motors placed beneath the track at intervals of about 1,500 ft. In a conduit between the rails, similar in construction to a cable-railway conduit, revolves a smooth cylinder, or series of cylinders coupled together at the ends about 6 in. in diameter. These cylinders are to be kept in continuous rotation by the compressed-air motors. An adjustable blade or arm projecting from the bottom of the car, and passing through the narrow slot into the conduit, carries at its end a group of friction-wheels, which may be pressed down forcibly upon the upper quarter of the revolving cylinder. The plane of revolution of these friction-wheels may be changed by an ingenious device controlled by a lever, to be operated by the driver of the car. While the friction-wheels revolve in the same plane as the cylinder, the frame supporting them is at rest, but the moment the axes of the wheels are thrown out of line with that of the cylinder, by a movement of the lever, the frame is driven along the cylinder by the diagonal travel of the wheels, which is similar to that of the traveling ink-distributer on some of the old-fashioned printing-presses. The speed of the car is regulated by the angle of inclination of the friction-wheel axles, the cylinder revolving continuously in one direction at a uniform speed.

The First Compound Locomotive.—We have lately received information which appears to show that the United States was the first country in which a successful compound locomotive was built and operated. About 1870 or a little earlier the Remington Company built at their works at Ilion, N. Y., some steam-actuated suburban cars for the Worcester & Shrewsbury Railroad, and one of them had the engines compound. The motors were used on a grade of 185 ft. to the mile, and they worked very satisfactorily, but the compound was noted as being more powerful and much more economical on the fuel than the others. This machine had an upright boiler with a steam superheater on the top. There were two cylinders, one 5 × 12 in., the other 8 × 12 in., connecting with crank-pins outside of the wheels, set at right angles. The cylinders were inclined about ¾ in. to the foot. A common shifting-link motion was used to actuate ordinary slide-valves. Provision was made for using steam direct from the boiler in both cylinders when starting and when the work to be done was particularly heavy. When working live steam in both cylinders it was supplied through the steam-chest for the high-pressure cylinder, and exhausted direct into the stack, each cylinder having been provided with an exhaust-pipe that led to the atmosphere. When working compound the steam passed from the high-pressure cylinder through the superheater to a steam-chest connected with the low-pressure cylinder; the superheater and steam-chest acting as a receiver. Changing from simple working to compound was done by means of an intercepting valve which was located in the steam-chest of the high-pressure cylinder. This was a D slide-valve, with ports in cylinder for the exhaust steam either to pass out to the atmosphere or to the receiver of the large cylinder, according to the position of the valve. When the valve was in position to allow the exhaust steam from the small cylinder to go out to the atmosphere, the passage for live steam was open to the chest of the large cylinder, and when the valve was changed to send the exhaust steam into the receiver the passage for live steam was closed.

The motor was built after the design of the patentee, who also invented the Baxter engine. After working for several years the boiler failed, and the machine was taken to the Rhode Island Locomotive Works, where a new boiler was put in with submerged flue tubes. After this change the motor worked without the superheater part of the receiver, and was said to be still more efficient. It was at work till within a very few years. This information we have received through the kindness of Mr. D. A. Wightman, of the Pittsburgh Locomotive Works, and Mr. H. F. Colvin, of the Rue Manufacturing Company.—*National Car & Locomotive Builder.*

Behavior of Steel under Mechanical Stress.—Mr. C. H. Carus-Wilson read a communication on this subject before the Physical Society (British) on December 6 last, of which *Nature* gives the following abstract:

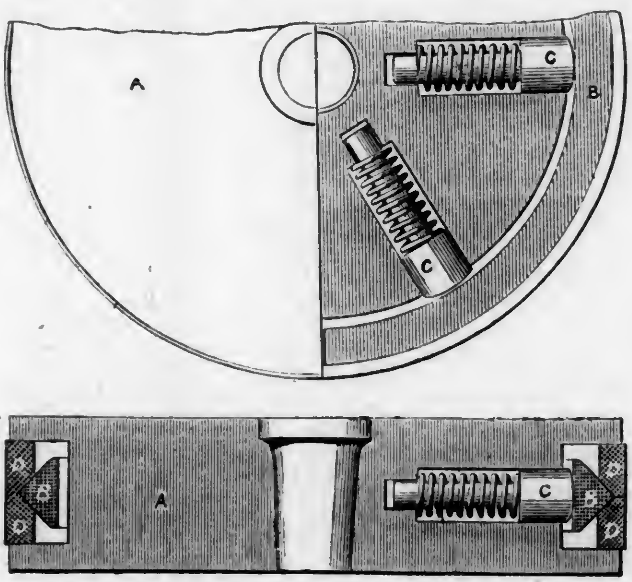
"This is an inquiry into the properties of steel as illustrated by the *stress-strain* curves given in automatic diagrams from testing machines, and by magnetic changes which take place during testing. After pointing out that the permanent elongation of a bar under longitudinal stress consists of a sliding combined with an increase of volume, the Author showed that the yield is caused by the limit of elastic resistance (ρ) parallel to one particular direction in the bar (generally at 45° to the axis) being less than along any other direction. When this lower limit is reached, sliding takes place in this direction until the hardening of the bar caused thereby raises the limit of elastic resistance (in the direction referred to) to that of the rest of the bar, after which the stress must be increased to produce further permanent set. From considerations based on the stress-strain curves of the same material when hardened to different degrees by heating and immersion, etc., it was concluded that the increase of ρ during yield is the same for all the specimens, and that the yield is a measure of the hardness. The question of discontinuity of the curves about the yield point was next discussed, and evidence to the contrary given by specimens which show conclusively that the yield does not take place simultaneously at all parts of the bar, but travels along the bar as a strain wave. In these specimens the load had been removed before the wave had traversed the whole length; and the line between the strained and unstrained portions could be easily recognized. As additional evidence of continuity, the close analogy between the stress-strain curves of steel of various degrees of hardness,

and the isothermals of condensable gases at different temperatures, when near their point of liquefaction, was pointed out; the apparent discontinuity in the latter probably being due to the change from gas to liquid taking place piecemeal throughout the substance. In seeking for an explanation of the hardening of steel by permanent strain, the Author was led to believe this due to the displacement of the atoms within the molecules of the substance. To test this hypothesis, experiments on magnetization by stretching a bar in a magnetic field were made; these show that the magnetization increases with the stress up to the yield point, and is wholly permanent when approaching that point. On comparing his results with Joule's experiments on the elongation of loaded wires produced by magnetization, the Author infers that there are two kinds of elongation—first, that produced by relative motion of the molecules, and secondly, an elongation resulting from a straining of the molecules themselves. To this latter straining the hardening by permanent strain is attributed, and this view seems compatible with the results of Osmond's researches on the hardening of steel."

An Air Pump of 1675.—At a recent meeting of the British Physical Society the President exhibited the air pump constructed by Otto von Guericke in 1675, which had recently been acquired by the Physical Society. This pump is still in a thoroughly workable condition, with the exception of the glass vessel, which has been renewed. The pressure in this receiver could be reduced to 20 mm. of mercury, by means of the pump. The celebrated Magdeburg hemispheres have also come into the possession of the Society, and were exhibited at the same time; they are perfect except in the want of the leather packing.

Vortex Blast Pipe.—In an inaugural address to the Society of Civil and Mechanical Engineers, Mr. Henry Adams, Professor of Engineering at the City of London College, in referring to the visits paid by the Society during the past year to the works of the London & Southwestern Railway, stated that, through the economy effected by the vortex blast pipe, of which Mr. William Adams, the Locomotive Superintendent of that line, and himself were the joint inventors, the saving to the company on its coal bills had amounted to nearly £50,000, independent of other advantages from its use.

A Solid Block Piston.—The accompanying illustration, from the London *Engineer*, shows a design for a solid block piston, made by Mr. T. Thompson, of Leeds, England, and patented by him in that country. Its construction will be



readily understood: *A* is the piston block; *B* the internal ring; *C* plungers with springs; and *D* the packing rings. This piston is said to be giving perfect satisfaction to those using it.

Compound Locomotive for South America.—A compound locomotive of the Worsdell and Von Borries system has recently been completed at the Hyde Park Locomotive Works, Glasgow, Scotland, for the Argentine Midland Railroad. The engine is of the American type, with four coupled drivers and a four-wheeled truck, and has one high-pressure cylinder on one side of the engine and a low-pressure cylinder on the opposite side. The principal dimensions are as follows: Diameter of high pressure cylinder, 16 in.; diameter of low-pressure cylinder, 23 in.; stroke of both cylinders, 24 in.; diameter of driving-wheels, 5 ft. 6 in.; grate area, 16.5 sq. ft.; heating surface, fire-box, 79 sq. ft.; heating surface, tubes, 822 sq. ft.; heating surface, total, 901 sq. ft. The total weight of the engine in working order is 38¼ tons, of which 23¼ tons are carried on the driving-wheels. The tender is carried on two four-wheeled trucks.

An Electric Engine Controller.—Mr. E. Dixon, of Hull, England, has invented and patented an apparatus intended to cut off the supply of steam to an engine by means of a current of electricity, the advantage being that the motion of the engine can be arrested almost instantly by completing an electric circuit at any part of a shop.

Fig. 1 shows a side elevation and fig. 2 a front elevation of the apparatus itself, which is connected by suitable gearing (not

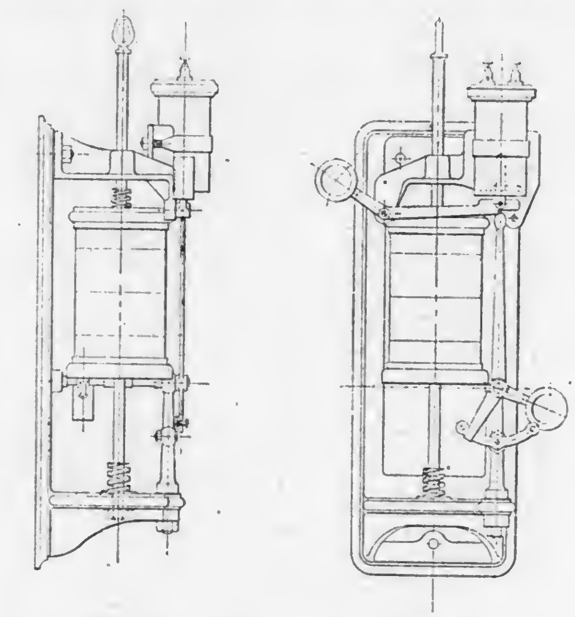


FIG. 1 FIG. 2.

shown in the figures) to the lever of the throttle-valve of the engines. The apparatus consists essentially of a raised weight, which is capable of sliding on a central spindle. This weight is held in a raised position by means of a catch lever. This lever carries a soft iron core, which is situated in a solenoid shown at the top right-hand corner of the figures. This solenoid, when connected with an electric battery, raises the soft iron core inside and lifts the catch lever. The weight is thus disengaged and falls. The top of the spindle which passes through the weight is attached to a chain or other mechanism, and by this means the throttle-valve is closed. The coiled spring shown at the bottom of the spindle under the weight acts as a buffer. The apparatus has been successfully applied to several engines, and seems capable of still further applications.—*The Steamship.*

Water Power for Electric Lighting.—We note from our foreign exchanges that much interest is being taken in the utilization of water power for electric purposes. The *Zeitschrift für Elektrotechnik* describes an electric lighting plant at Gastein, in Austria, the power for which is supplied by the River Ache. The available head of water is about 70 ft., and the turbine wheel used gives about 120 H.P., making 140 revolutions per minute. The water is conveyed to the wheel through a 28-in. pipe 230 ft. long, and besides the lighting plant drives two small mills and a small pumping plant in connection with the hot springs at that place. There are four dynamos, one held in reserve, and the plant supplies 1,000 incandescent lamps of 16 candle power each.

Another recent application of water power is at St. Hilaire, France, where the electric lighting station is on the banks of the small River Vouroux, 2½ miles from the town. The water is stored up in three reservoirs, about three hours being necessary to fill them, and the supply thus obtained works two water-wheels successively for eight hours a day. The wheels are 16½ ft. in diameter, and at a speed of seven revolutions per minute develop 10 H.P. each.

In Austria preparations are being made to light the town of Trient by water power. The lighting station at Innsbruck in the Tyrol takes its power from a small river about two miles away, the dam being so located as to give a head of no less than 377 ft. The power available amounts to over 600 H.P., but only two turbines of 150 H.P. each are at present in use.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

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NEW YORK, MARCH, 1890.

HOW rapidly the older generation of engineers is passing away, we are reminded by the death of Mr. William J. McAlpine, following a few weeks after that of Horatio Allen. They were nearly the same age; both had their share alike in the beginning of the great public works in this country and in their later development, and to both the present generation is deeply indebted, for they were among those who may be said to have created the science of engineering in America.

ON another page will be found the first of a series of plates showing Howe truss bridges of different lengths. This will include bridges from 30 ft. up to 150 ft. span, and each plate will be accompanied by complete bills of material both for the timber and the iron work. The intention is to make these plates and the accompanying bills of material so complete that no further instructions will be needed, and they can be used at once as working drawings. The designs have been made by an acknowledged expert, the strains carefully calculated, and all the details worked out in very complete fashion.

Strange as it may appear, there is no series of this kind in existence, or at least accessible to engineers generally; and it is believed that these plans will be of great service to engineers who are called upon to build wooden bridges —and there are very few who are not required to do so at some time or other. It will be many years yet before wood is entirely displaced as a bridge material, and probably there is no railroad engineer now living who will not have in his charge at some time wooden bridges; while for highway work their use will continue as long as timber is reasonably cheap and abundant in this country —and that is a term to which no one will venture yet to place a limit.

THE Baldwin Locomotive Works are just completing 15 engines which are among the heaviest in the country. They are of the 10-wheel pattern, with three pairs of driving-wheels coupled and a four-wheeled truck. The cylinders of these engines are 20 in. in diameter and 24 in. stroke; the driving-wheels are 5 ft. in diameter. The boilers are 64 in. diameter of barrel, have Wootten fire-boxes and plain (not extended) smoke-boxes. These engines are for the Philadelphia & Reading Railroad, and are intended to run fast freight trains, but will very probably be used also for heavy passenger service when needed.

THE College of Civil Engineering of Cornell University purposes collecting in a concise and practical form for use or reference facts bearing on the pollution of drinking waters. Engineers everywhere are asked to co-operate, and will, no doubt, readily extend their aid. Samples of water sent will be submitted to thorough analysis, and notes or reports made on this subject will be carefully filed and used. Due credit will be given to all persons contributing, and the results obtained will be published for the benefit of the profession. Engineers desiring to give their aid may communicate with Professor E. A. Fuertes, Director.

In this connection it may be noted that the College is well equipped with laboratories for research into engineering problems, tests of material, etc., and is always ready to give its aid to such investigations.

SOME remarkable things have been told of the Spanish submarine torpedo boat, the *Peral*, and these seem to be confirmed if correct reports are given of tests recently made at Cadiz. From these accounts it appears that the speed of the boat while running on the surface was about eight knots an hour, while under water she ran between five and six knots an hour. The boat was navigated for over three hours with all connection with the outer air completely shut off, and for more than two hours in fighting trim, with only 4 in. of the observation turret above water. One continuous trip of 40 minutes was made with the boat entirely under the water, during which time she traveled about four miles. The machinery is said to have worked without the slightest trouble, and during the submarine trips the crew did not experience any inconvenience whatever.

THE 110-ton guns built for the British Navy have not done very well so far, several of them having proved defective. Meantime much opposition is manifest among experts to the construction of any more of these guns. It is pointed out that for the cost of one of these guns a number of smaller ones could be constructed, which in all probability would be more effective in actual service. Moreover, the cost of firing these guns is so great—each shot requiring an expenditure of nearly $1,000—that it will be difficult to practise with them, or, indeed, to give them a proper test for their efficiency. Italy and England are the only nations which have adopted these huge guns. France has not gone beyond 74 tons in the weight of her largest cannon, and no other country has exceeded 50 tons. From present indications, it is doubtful whether the number of those built in England will be much increased.

THE total tonnage of new vessels set afloat on the Lakes this year, not including tug-boats and such small vessels, was close upon 94,000 tons, which, although somewhat less than was reported for 1888, shows great activity in shipbuilding. The tonnage of the present season, moreover, includes a much larger number of steamers than in 1888, when the report was swelled by a number of schooners

and barges of large carrying capacity. The list for this season includes 98 steamers, having a total tonnage of 80,138 tons, and 23 schooners and barges of a total of 13,743 tons. The largest steamer on the list was of 2,670 tons measurement. More of these vessels than ever before were of steel or iron, and the steamers generally were supplied with engines of the latest and most economical pattern.

A GENERAL rural and forest exposition will be held in Vienna, Austria, in 1890, beginning May 15 and lasting until the end of October. The exposition is intended, in the first place, to show the progress of agriculture and forestry in Austria; but in several of the groups it is intended to make it an international exposition, in which all countries will be invited to take part. The exposition will include products of agriculture and forestry; live stock; agricultural machinery; plans for drainage; methods of husbandry, and designs for all sorts of constructions affecting rural and forest work. The articles which foreign exhibitors are specially requested to send are agricultural tools and machinery of all sorts. The Secretary of the General Committee is Herr A. Hochegger, who may be addressed at Vienna.

THE Government of New South Wales is trying to secure the establishment of locomotive works in that Colony, and offers to give an order for 100 locomotives to any builder who will locate himself there, and will erect suitable shops, furnished with modern tools and appliances. The building of the 100 engines may extend over three years.

All or nearly all of the railroads in New South Wales belong to the Government, and there were last year 431 locomotives employed upon them. It would seem as if the large capital required for well-equipped locomotive shops could hardly be safely invested unless there was a strong probability that orders could be secured from the other Australian colonies.

THE Railroad Commissioners of New Zealand in their last report, which covered the year ending March 31, 1889, state that there are now 1,777 miles of Government railroads in operation. This includes nearly all the railroads in the Colony, the only private lines being a few short branches connecting with coal mines, etc., and one short road in the Middle Island. The Government roads, we believe, are all of 3 ft. 6 in. gauge.

The total earnings of these lines for the year were $4,828,257; the expenses (64.8 per cent.) were $3,131,698, leaving a net return of $1,696,759. This does not indicate by any means a heavy traffic, as the gross earnings were only $2,706 and the net earnings $955 per mile worked; but it is probably as much as could be expected from a system which necessarily includes a good many miles of unproductive lines.

The total capital invested in the Government lines amounts to $65,208,500, which is about $36,700 per mile—not a very high cost when we consider that there are in the system some very expensive mountain lines, including several sections where it has been found necessary to use the rack-rail. The net earnings last year were 2.6 per cent. on the capital invested, an improvement over the previous year, when only 2.3 per cent. was earned.

The passenger traffic last year shows a considerable falling off, which was due chiefly to dull times; but there was an increase of about 11 per cent. in freight business. Considerable reductions in rates were made during the year, however, so that the earnings were about the same as in the previous year, the increase in the net earnings being obtained entirely by diminishing the expenses. The Railroad Commissioners do not consider that there is any probability of a rapid gain, and say in their report that the growth of the business must be very gradual, from the nature of the country and of the people.

The equipment of these roads consists of 272 locomotives, 512 passengers cars, and 8,156 freight cars. Of the locomotives about 40 are of American pattern, but nothing is said in the report as to any comparison between the performance of the different classes. The largest locomotives in use are American consolidation engines with 15 × 18 in. cylinders, and a few Fairlie double-truck engines having four 10 × 18 in. cylinders. Most of the cars are of English pattern, although about half of the passenger cars are long cars carried on two trucks of the American type. The rails in use are chiefly of steel, and vary in weight from 40 to 53 lbs. to the yard, the latter being the heaviest.

COUNTERBALANCING THE REVOLVING AND RECIPROCATING PARTS OF LOCOMOTIVES.

(*Continued from page 54.*)

THUS far we have considered the engine as working without steam in the cylinders. It may be thought that the conditions of working are very materially altered if pressure is exerted on the pistons.

That such is not the case can be shown if it be supposed that we had an engine with a double crank and two cylinders located on opposite sides of the crank, as shown in fig. 13. If the crank should turn without steam in the cylinders, obviously the reciprocating parts of each would exactly balance each other. If steam was admitted to one of the cylinders, so as to turn the crank at the same speed that it was turned without steam on, then it is plain that the movement of the reciprocating parts—their acceleration and retardation, their inertia and momentum—will be the same with steam on as they were without steam. As they balanced each other at the same speed without steam on, they will be in equilibrium when steam is admitted to one or both cylinders.

As it has been shown that a counterweight opposite the crank will balance the movement of the reciprocating parts, and as it is also obvious that one piston, etc., will balance another, we may disconnect one piston and substitute a counterweight to balance the other piston and its connected parts.

It is true that if steam is admitted into the front end *S* of the cylinder, fig. 12, that it will cause some disturbing effect, but it is not due to the motion of the reciprocating parts, but to the pressure of the steam. It would press equally on the cylinder-head *t* and on the piston *P*, and these pressures would balance each other. The pressure on the cylinder-head is, however, communicated to the cylinder and frame, that on the piston to the crank-pin, wheel, and thence to the frame, so that they both act in opposite directions. The only cause of disturbance is due to the fact that the pressure on the cylinder-head is communicated directly to the frame and thence to the axle *A*, fig. 12. As the pressure on the piston is communicated to the crank-pin *c*, we will imagine the spoke *A c k* of the

wheel to be a lever, and that the pressure on the cylinder-head acts against the axle, as indicated by the dart *l*, and that the pressure on the piston is exerted in an opposite direction on the crank-pin at *m*. If *k*, the point of contact of the wheel with the rail, is regarded as the fulcrum of the lever, then one force acting on the end of the lever at *A*, and another equal force acting in the opposite direction at *c*, between the end *A* and the fulcrum *k* will push the upper end of the lever ahead. It is this action which propels the engine.

Fig. 10

Fig. 11

As only a part of the backward force acting on the piston and crank-pin is exerted against the axle *A*, and the whole of that on the cylinder-head acts against the axle, we have an excess of pressure against *t* which acts on the engine frame and tends to push one side of the engine ahead and thus cause nosing, but other than that it has no disturbing effect on the action of the working parts. If we will imagine that the wheels are securely bolted fast so that they cannot turn, then the admission of steam into the cylinders would not disturb or affect their equilibrium.

It is often supposed, too, that by giving an engine lead or compression that the disturbing effect of the momentum of the reciprocating parts is neutralized. That this is not the case will appear if we imagine that the piston should strike the cylinder-head at the end of each stroke. It would thus be brought to a state of rest by a violent blow. If a piece of india-rubber was interposed between the piston and cylinder-head the blow would be less violent, but the energy of the moving parts would still be communicated to the cylinder-head, as it would be if a cushion of steam was interposed, as it is when the engine has lead or compression, and the momentum would then be overcome in a less violent way than it is by a cushion of india-rubber.

But while the motion of reciprocating parts may be balanced by a revolving weight, the latter causes a disturbing effect on the machine, for the reason that the momentum and inertia of the reciprocating parts act in a horizontal direction only, whereas the revolving weight has vertical as well as horizontal movement. Thus, if the crank and counterweight are arranged as shown in fig. 13, the counterweight *W*, in order to balance the reciprocating parts, must be heavier than the weight concentrated at the crank-pin *c*, consequently, the counterweight exerts more centrifugal force than the weight at the crank does, and when they are in the position represented the weight *W* would exert an upward pressure greater than the downward pressure at the crank. When they are at the dead points, as shown in fig. 10, then if the counterweight *W* is equal to the weight of the revolving parts at *c* and the reciprocating parts, the centrifugal force of the former, and the momentum and inertia of the latter will be just equal to the centrifugal force of *W*. When the crank is between the dead points and the two quarters of its revolution, as shown in fig. 11, the centrifugal force of the counterweight is exerted in a diagonal or partly vertical and partly horizontal direction. Between the two dead points, therefore, a counterweight equal to the weight of both the revolving and the reciprocating parts creates a vertical disturbance, which is greatest at the two quarters of the revolution and increases from and diminishes toward each of the dead points, where it disappears entirely.

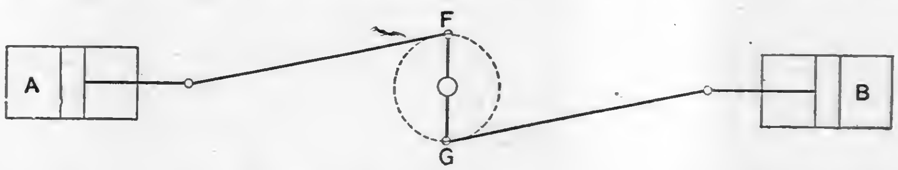


Fig. 13.

The counterweights for reciprocating parts, like those for revolving parts, need not be placed at the same distance from the center of the wheel as the crank-pin, the essential thing in each case being that the products of their weights multiplied into their distance from the center of the wheel should be equal.

As an illustration of the method of calculating this upward and downward disturbance, and to show how it acts, we will take the case of an engine with four driving-wheels 62 in. diameter and 24 in. stroke, at a speed of 60 miles per hour. At that speed such wheels would revolve 325 times per minute. If the reciprocating parts on one side weigh 624 lbs., and if their whole weight is balanced by weights of 187.2 lbs., in each wheel, the centers of gravity of which are 20 in. from the center of the wheel, then by the rule given the centrifugal force of each weight would be 11,205 lbs., and at 70 miles per hour—not an unusual speed for locomotives—it would be 15,318 lbs. This force, it will be observed, is greater than the weight which in many instances rests on a single wheel of a locomotive, and shows why less than the whole of the reciprocating weight should be counterbalanced.

The manner in which the force of the counterweight is exerted on the wheels while they are in motion is illustrated

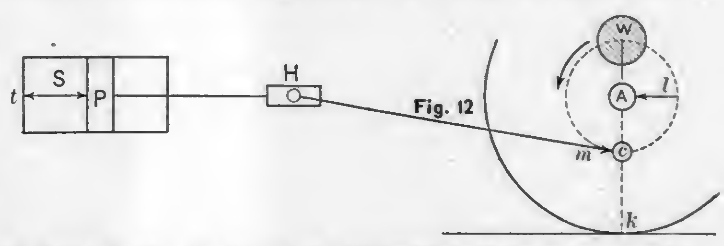


Fig. 12

in figs. 14–18. In fig. 14 a driving-wheel is represented at *D*, with its crank-pin *C* at the forward dead point. *c* is the center of gravity of the counterweight *W*. In this position its centrifugal force is exerted in a horizontal direction only, as indicated by the dart *d*, whose length *o c* will be supposed to represent the magnitude of the force. Figs. 15, 16, 17, and 18 represent the position of the driving-wheel at the end of the first, second, third, and fourth quarters of a revolution, and the circles 4, 8, 12, and 16 show the axle when the wheel is in these positions, and the dotted circles 1, 2, 3–15 represent the inter-

mediate positions of the axle during each sixteenth of a revolution. When the axle is in the position 1, then the center of gravity of the counterweight is at c 1, and its centrifugal force acts in the direction shown by the dart d 1. Supposing, again, that the length of the dart d 1 represents the magnitude of the centrifugal force, and that a

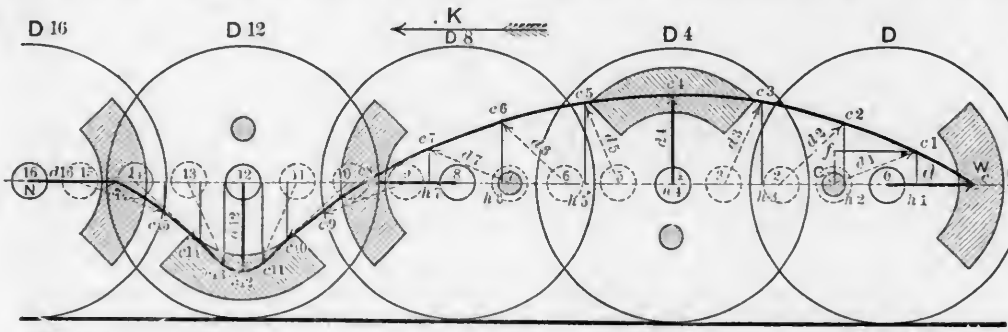


Fig. 18. Fig. 17. Fig. 16. Fig. 15. Fig. 14.

parallelogram f, c 1, h 1, h 2, is drawn whose sides are vertical and horizontal and of which d 1 is a diagonal, then by the principle of the parallelogram of forces c 1, h 1 the vertical side will be equal to the vertical component or vertical effect of the force d 1. In the same way similar parallelograms could be drawn for the darts d 2, d 3, etc., but all that is needed to represent the vertical effect for each position of the wheel is to draw vertical lines c 2 h 2, c 3 h 3, etc., from extremities c 2, c 3, etc. of the dart, to the horizontal line $M\ N$ passing through the centers of the axle, and these vertical lines will represent the vertical effect of the centrifugal force of the counterweight in each position, c 1, c 2, c 3, etc., of its center of gravity. If we draw a curve c, c 1, c 2 – c 16 through each position of the center of gravity of the counterweight during a whole revolution, its vertical distance above the center line $M\ N$ will represent the upward force exerted by the counterweight, and the distance of the curve below the line $M\ N$ will represent the downward pressure of the counterweight, and the curve will represent to the eye the vertical strains exerted by the counterweight during a whole revolution of the wheel. It will be seen from the diagram that when the wheel is in the position indicated by fig. 14, as already explained, the centrifugal force is exerted in a backward direction—assuming that the engine is running from the right toward the left side, as shown by the dart K. When the wheel has turned a quarter of a revolution, as shown at fig. 15, then the centrifugal force d 4 is exerted upward ; in fig. 17, d 12 acts downward, and at fig. 18 the centrifugal force is again backward.

As the crank on the other end of the axle is at right angles to the one on this side, the centrifugal force of the counterweight on that side also acts at right angles to the one on this side, so that when the counterweight W exerts a backward horizontal pressure the opposite one acts vertically either up or down, according to its position in relation to W. When W acts vertically, as in fig. 15, then the opposite counterweight exerts its force horizontally.

The vertical disturbance of the counterweight may be lessened by balancing only a part of the weight of the reciprocating parts. When this is done there is more horizontal disturbance in the working of the engine than there would be if the whole of the reciprocating parts were balanced, but this is not considered so great an evil as the excessive vertical disturbance which necessarily results when the counterweight is sufficient to balance the whole of the horizontal momentum of the reciprocating parts. Whether a third, a half, two-thirds, or any other proportion of these parts should be balanced is a question which must be largely decided by experience and practical considerations. If a half is balanced it divides the vertical and horizontal disturbance equally, but there is still much difference of opinion with reference to which is the greater evil, vertical or horizontal disturbance.

In another article some other disturbing action of counterweights will be discussed.

NEW PUBLICATIONS.

A Text-Book on Roofs and Bridges: Part II, Graphic Statics: by Mansfield Merriman, Professor of Civil Engineering, and Henry S. Jacoby, Instructor in Civil Engineering in Lehigh University. New York; John Wiley & Sons, 15 Astor Place (price, $2.50).

The first part of Professor Merriman's work has met with general acceptance, and the second part, which forms the volume of 125 pages now before us, seems likely to meet with similar success. Its general plan and object can best be explained by the following paragraphs from Professor Merriman's preface :

The course of instruction in roofs and bridges given to students of civil engineering in Lehigh University consists of four parts : first, the computation of stresses in roof trusses and in all the common styles of simple bridge trusses ; second, the analysis of stresses by graphic methods ; third, the design of a bridge, which includes the proportioning of details and the preparation of working drawings ; and fourth, the discussion of cantilever, suspension, continuous and arched bridges. In the following pages the second part of this course is presented, together with additional matter, so as to form a tolerably complete treatise on Graphic Statics as applied to the discussion of common roofs and bridges.

In an elementary text-book of this kind it is not expected that much will be found that is new except method of arrangement and presentation. Attention is called, however, to the abbreviated processes employed in some of the diagrams for wind-stresses, to the determination of stresses due to initial tension, and to portions of the analysis of maximum moments and shears under locomotive wheel-loads as possessing points of novelty and practical value. These new features are due to the experienced Instructor whose name appears on the title-page in connection with my own ; the larger portion of the text has also been written by him, and the cuts and plates are his work.

The book is divided into three parts, Chapter I treating of general principles and methods ; Chapter II of roof trusses, and Chapter III of bridge trusses. An appendix contains answers to problems. While intended, as stated above, mainly as a text-book for students, the book will be useful to engineers also, who will find its clear statements and style attractive.

As in Part I the book is bound with blank leaves between the pages. These will be found very convenient for students to record permanently such additional notes and computations as may be required in working out the problems.

Care of Cash by Agents and Conductors; its Collection, Custody, Use and Transmission to the Company's Treasury: by Marshall M. Kirkman. Chicago; published for the Author.

This is the latest addition Mr. Kirkman has made to the literature of railroad accounts, a field which he has made and occupied so successfully, that it may be said he has no rival therein. Like Mr. Kirkman's former works, the "Care of Cash" is a valuable book to those to whom it is addressed. It has all the merits and all the faults of his previous volumes. The directions, suggestions, forms, etc., are good, but there is a little too much of it. Some day, when the pen of the Author is somewhat worn, and he feels that it will not run quite so fast as he now uses it, he may be induced to make a revised edition of his works, somewhat in the form of the Revised Statutes, and they will be not only a monument to his acute sense of what is good in railroad accounting, but even a more valuable addition to the railroad literature of the country than they are in the form in which they are now published. Still in its present form we can recommend the "Care of Cash" to all those interested in railroad accounts.

Practical Blacksmithing, Volume II: Compiled and Edited by M. T. Richardson, Editor of the Blacksmith and Wheelwright. New York; M. T. Richardson, 84 & 86 Reade Street, (illustrated, 259 pages; price, $1).

This is a compilation of articles published from time to time in the *Blacksmith and Wheelwright;* not merely thrown together, however, but carefully arranged and edited. To these Mr. Richardson has added an introduction treating of the history of iron and steel and of artistic iron work.

Volume I was devoted chiefly to shop economy and arrangement, methods of constructing forges, and similar matters. Volume II treats chiefly of tools and of the best and most convenient ways of making them. It is very fully illustrated, and the engravings, though not of the best quality, are generally plain and clear. The book is of the most practical kind, and is full of hints and ideas which must be of value to every blacksmith.

Annual Report of the Chief of the Bureau of Steam Engineering, Navy Department, for the Year 1889; George W. Melville, Chief of Bureau. Washington: Government Printing Office.

Like the report of the Bureau of Construction and Repair, this report covers a period of great activity in the Navy Department. The mere summary of the designs for new engines prepared during the year occupies a considerable space, and while the report is not very long, it is evident that the Bureau has not been by any means idle. Besides the design and supervision of the new work, no inconsiderable time has been required for the repairs and maintenance of the machinery of older vessels. The recommendations made by the Chief of the Bureau are generally practical and in the direction of improving the service.

Annual Report of the Chief of the Bureau of Construction and Repair to the Secretary of the Navy for the Fiscal Year Ending June 30, 1889: Chief Constructor, T. D. Wilson, U. S. N., Chief of Bureau. Washington; Government Printing Office.

This report is of unusual interest at the present time, when so much work is in hand for the reconstruction of the Navy. Necessarily it contains much of the detail of official routine which is required in a report of this kind; but outside of this there is much of interest in its pages. Several of the new ships now under construction are described and illustrated and their present condition is given. A melancholy interest attaches to the excellent engravings of the *Trenton* and the *Vandalia,* lost in the great storm at Samoa.

A careful reading of the report shows the great variety of work that has required the attention of the Bureau, in the care of the old ships and the building of the new ones for the Navy, while the recommendations made for the improvement of the construction plant at the several navy-yards are worthy of careful consideration.

So much has been said of the new ships that many will be surprised to learn that the Navy is decreasing rather than increasing in actual numbers. The new vessels are more powerful and larger than the old, it is true; but their number so far is not great enough to make up for the wooden ships retired by the wear of time and service and the casualties of the sea.

Motive Power for Street Cars. New York; issued by the John Stephenson Company, Limited.

This neat little book contains the reports presented at the last meeting of the American Street Railway Association on Electricity as a Motive Power and on Motors other than Animal, Cable and Electric, with the discussions on the same; a paper read before the National Electric Light Association on Storage Batteries for Electrical Traction; and a paper on Cable Railroads in Australia. It is illustrated by a number of views of electric and cable cars built by the John Stephenson Company.

The pamphlet is a timely one, putting in accessible shape much valuable information on the subject of replacing animal power on street railroads by some kind of mechanical traction—a question which is now being discussed with interest everywhere.

BOOKS RECEIVED.

Elementary Manual on Steam and the Steam Engine: by Professor Andrew Jamieson. London, England; Charles Griffin & Company.

A Text-book on Steam and Steam Engines: by Professor Andrew Jamieson. London, England; Charles Griffin & Company.

Institution of Mechanical Engineers: Proceedings, July, 1889, Paris Meeting. London, England; issued by the Institution.

Statistical Annuary of the United States of Venezuela: 1889. Caracas; Printing Office of the National Government.

Hand-book of Freight Accounts. Handling Freight; Theory and Practice of Accounts; Rules and Regulations Governing Agents; Returns to be made by them: by Marshall M. Kirkman: Chicago; printed for the Author.

Commerce of the United States and other Foreign Countries with Mexico, Central America, the West Indies, and South America: Bureau of Statistics, Treasury Department. Washington; Government Printing Office.

Map of the Country Adjacent to Puget Sound, Embracing British Columbia and the Counties of Western Washington. Seattle, Wash.; Baker, Balch & Company, Engineers.

Revista Tecnologico Industrial: No. 12, December, 1889. Published by the Association of Industrial Engineers, of Barcelona, Spain.

Seventeenth Annual Report of the Commissioner of Railroads of the State of Michigan, for the year 1889: John T. Rich, Commissioner. Lansing, Mich.; State Printer.

Reports of the Consuls of the United States, Issued by the Bureau of Statistics, Department of State: No.

112, JANUARY, 1890—STEAMSHIP SUBSIDIES. Washington; Government Printing Office.

CENTRAL EXPERIMENTAL FARM, DEPARTMENT OF AGRICULTURE: BULLETIN NO. VI, JANUARY, 1890. Ottawa, Canada; issued by the Department.

HALSEY'S PATENT PORTABLE POWER DRILLING MACHINES: CATALOGUE AND DESCRIPTION. Morristown, N. J.; issued by James T. Halsey, Manufacturer.

ABOUT BOOKS AND PERIODICALS.

AMONG the new books now in preparation by John Wiley & Sons are Part II of Professor McCord's Kinematics; Professor Thurston's Handbook of Engine and Boiler Trials; a Manual of the Steam Engine, by the same Author, and H. C. Godwin's Engineers' Field Book.

Colonel Church continues his articles on John Ericsson in the March SCRIBNER, and among the illustrations will be reproductions of his first rough pencil sketches embodying the ideas subsequently developed in the *Monitor*.

Mr. William M. Goldthwaite, already well known as a publisher, has succeeded to the business of Hyde & Company, and has established himself at No. 107 Nassau Street, New York. His specialty is the publication and dealing in maps, atlases, charts, and other works in the geographical line, and his object is to make his office a bureau of geographical information. Such an intention deserves to succeed, and there is little doubt that it will do so.

The ECLECTIC MAGAZINE reaches us this year with a new cover and a new dress, but the contents are as good and the selections as ably made as they used to be when Mr. William Shakespeare presided over the title-page as their representative.

The paper of HARPER'S MAGAZINE for February which will be of most interest to many of our readers is the Talks with Edison, giving his reminiscences as to his earlier inventions and something about his methods of work. The army series is continued by an article on the British Army, by General Lord Wolseley. This series will be continued in the March number by the Army of the United States, written by General Wesley Merritt.

The WESTERN ENGINEER is a new monthly, issued by that enterprising firm, the Pond Engineering Company, of St. Louis. The number at hand contains some valuable matter, including a paper on Steam Plants for Electrical Service, by William H. Bryan.

The Power of Congress over Rates of Interstate Carriers, by John Totyl, in the OVERLAND MONTHLY for February is a severe criticism of the Interstate Commerce law, and an attempt to raise again the issue of the constitutionality of the law. In an Empire in Ruin, in the same number, John Bonner gives rather a gloomy picture of the present material and political condition of China, with some account of the causes which have led to it.

UNIFORM STANDARD TIME.

AT the annual meeting of the American Society of Civil Engineers in January, the special Committee on Uniform Standard Time—consisting of Messrs. Sanford Fleming, Charles Paine, Theodore N. Ely, J. M. Toucey, T. Egleston and F. Brooks—presented a report from which the following extracts are taken:

The last annual report of the Committee, together with other documents bearing on the question, have been published in pamphlet form and widely circulated. The railroad managers and others were asked to state their views as to the adoption of the new notation by the railroads of the country.

The Committee have to announce the receipt of 237 replies to the circular issued. Of these 17 are unfavorable and 220 favorable to adoption of the proposed change.

Persons answering the circular were requested to indicate the year when, in their opinion, the change might be effected, allowing sufficient time for such preparation as might be deemed necessary.

In the 220 favorable replies received, 27 named the year 1892; 68 the year 1891; 95 the year 1890; 30 gave no date.

Thus it appears that none of these replies give a later date than 1892, nearly half the whole number named the present year, and if we assume, what is highly probable, that the 30 persons who mention no date would concur in the views of the majority, no less than 84 per cent. of the whole number think the change might be effected not later than the year 1891, should a general assent be first expressed.

The last annual report was copied in the technical journals with favorable endorsements.

It has not come to the knowledge of the Committee that any journal has at any time expressed any opposition to the new notation.

The Committee has considered it advisable to tabulate the replies recently obtained with those received in previous years. It thus appears that between 500 and 600 prominent men in every section of the country have responded to the Society's interrogations, and of these an exceedingly small percentage have given expression to an opinion adverse to the early adoption of the new notation.

The list of those approving it includes 384 officials of railroads. The aggregate length of the railroads with which these officers are connected amounts to fully 135,000 miles, and although all of the officers on each line have not yet expressed an opinion, the Committee are inclined to believe that when heard from the greater number of them will express the same views on this question.

While the Committee ventures to congratulate the Society on the highly satisfactory results of the inquiries so far made, they are of opinion that, as the matter concerns so many people, it will be best to proceed with wise deliberations; they therefore beg leave to suggest that the ascertained facts be communicated to the journals above mentioned, and that further efforts be made to secure an expression of the greatest possible unanimity, especially among railroad men.

General unanimity satisfactorily established among those who control the railroads of the country, it will then be fit and proper for them to take decisive action. It is obvious that the change should be effected simultaneously six or twelve months after an agreed date, and the proper authority to determine the date is the General Time Convention.

The Committee cannot doubt that when the change to the new notation comes to be satisfactorily established the entire railroad system and the community generally will recognize that a public boon has been conferred not less valuable than that already conferred by the adoption of standard time.

The Committee has the satisfaction to report that the hour-zone system is now approved by the railroad administration in Austro-Hungary, soon to be followed, it is believed, in Germany, Italy and Switzerland. The reckoning of time in Great Britain and Sweden is already in harmony with the hour-zone system. The 24-hour notation has been adopted for railroad service in China.

The Committee deem it proper to bring to the notice of the Society that the Government of the United States has so far taken no action on the resolutions and recommendations of the Washington International Conference of 1884. As the reforms in time-reckoning so largely adopted and proposed to be adopted in this country are in harmony with the resolutions of the Conference, and as questions are constantly arising as to the legal aspect of standard time, it would be in the public interest to have the recommendations of the Conference authoritatively recognized,

and also perhaps some satisfactory statutory enactment legalizing the changes made and contemplated in respect to the reckoning of time.

The Committee respectfully suggest that the Society should memorialize the United States Government on this subject.

A form for this proposed memorial and a list of the railroad officers approving the 24-hour system accompany the report.

THE DEVELOPMENT OF ARMOR.

BY FIRST LIEUTENANT JOSEPH M. CALIFF, THIRD U. S. ARTILLERY.

(*Continued from page* 89.)

VIII.—PRACTICAL APPLICATION ABROAD (CONTINUED).

THE next step in English construction is represented by the *Nile* and *Trafalgar*, in which the displacement is carried from the 9,000 tons of the *Collingwood* to about 12,000 tons. The armored belt is extended to 230 ft., with an armored citadel 193 ft. long in the central fort of the ship, with a turret at either end, mounting two 68-ton guns each, with a maximum thickness of armor amidships of 20 in., thinning to 14 in. at the ends. Instead of the long, unprotected space between the turrets, as in the *Admiral* class, there is a central box battery, with 5-in. armor, affording protection for the secondary battery as against guns of moderate caliber. These vessels do not differ radically from the new turret battle-ship shown in fig. 4.

In November of tast year the British Board of Amiralty decided upon the construction of eight new battle-ships during the coming year, of about 14,000 tons displacement. After considerable discussion it was decided that seven of these ships should be barbette and one turret. Except in this regard the ships of the two designs are to be identical in their details. The advantages claimed for the barbette over the turret designs are that the guns are carried some 7 ft. higher above water, and that the weight saved from the turrets can be utilized in adding to the height of the redoubts in which the turret bases stand. They lack, however, the protection given to the guns in the turret ship. The new designs are expected to carry 4,550 tons of armor. Figs. 4 and 5 show the manner of armor distribution. The armor protection is a belt of 18 in. compound armor, two-thirds the length of the ship, $8\frac{1}{2}$ ft. in width, 3 ft. above and $5\frac{1}{2}$ ft. below the water-line, with transverse armored bulkheads; a 3-in. steel deck, and a strong protective under-water deck before and abaft the belt. Above the belt the broadside guns are to be protected by 5 in. of steel armor, $9\frac{1}{2}$ ft. in width. The turrets are to have 18 in. and the barbettes 17 in. of compound armor. After all the criticism that has been indulged in at the expense of the Italian Government for constructing the huge vessels of the *Italia* type, England is now committed to the same line—the new ships falling but little short of the tonnage of that vessel. The cost of one of these new ships, including armament, will reach very nearly a million pounds sterling.

Next in importance are the belted or armored cruisers, the distribution of armor upon which is shown in fig. 6, representing the English ships of the *Australia* class, which may be taken as a type of the best of this type of ships. Here we have a water-line belt of 10 in. of armor, extending about 200 ft. over the vitals of the ship; at the ends of the belt a 16-in. compound armored bulkhead, while on top of this belt is a flat protective deck of 2 in. steel. Where the belt ends this deck slopes down to the sides with an increased thickness of one inch, and also slopes longitudinally to a point considerably below the water-line. This belt, $5\frac{1}{2}$ ft. in width, covers 18 in. above and 4 ft. below the load water-line. With a displacement of 5,000 tons, a speed of 18 knots, a liberal coal supply, and means for discharging torpedoes, the English claim for them superiority over any vessels of their kind afloat.

In the protected cruiser side or vertical armor is wholly wanting, and as a substitute for the protection of magazines, machinery, boilers, etc., we find a greater or less thickness of horizontal armor laid upon a deck running from end to end of the vessel, with a level amidships of about that of the water-line and sloping to the sides at a

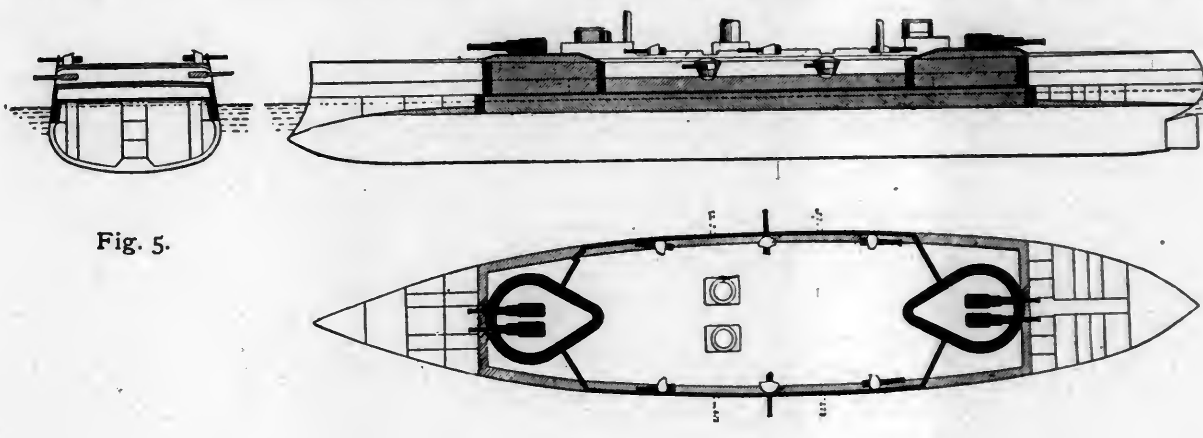


Fig. 5.

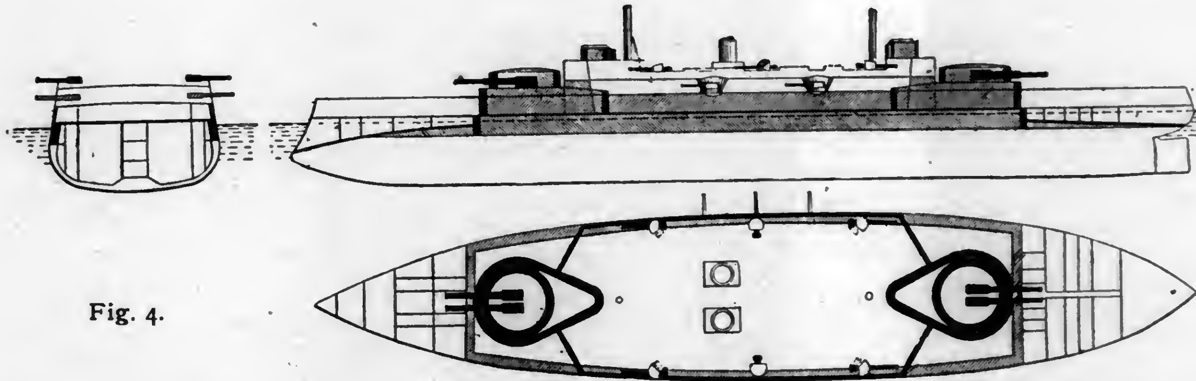


Fig. 4.

point considerably below. Fig. 7 represents the English vessels of the *Mersey* class. In them the steel deck is 2 in. thick amidships and 3 in. on the slope, which strikes the side 4 ft. below the load water-line. The boilers, etc., are, as shown in the cut, protected by many feet of thick-

of the recent English battle-ships planned within the past twelve months, we shall find a return toward first designs in the amount of space sought to be protected. Better still, the reconstructed plan of the *Dupuy de Lôme* will show as a ship that is almost a second *Gloire*—a 4-in. ar-

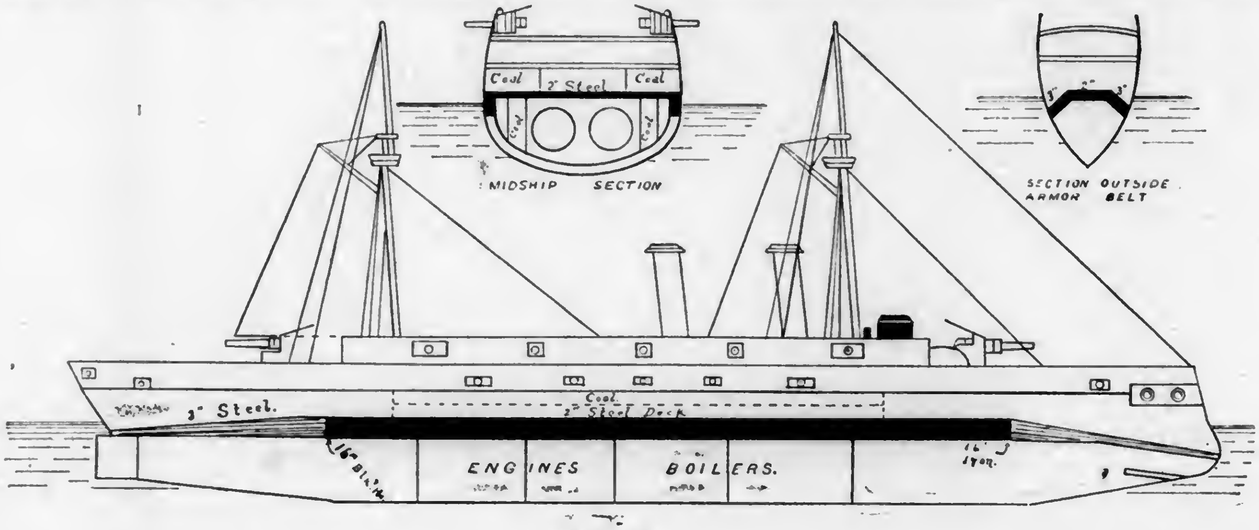


FIG. 6.

ness of coal. No protection for the battery is provided for except that afforded by the shields on the individual guns. These vessels have a displacement of 3,500 tons and an estimated speed of 18½ knots. In the cruiser *Blake*, which the English naval authorities launched the other day at Chatham Dock Yard, a new departure was made. Although with a displacement equal to that of many of their battle-ships—9,000 tons—no armor whatever is provided

mor protection given to the entire sides. This in addition to the armor upon the gun-towers.

The original *Gloire* gave 15 per cent. of her 5,500 tons displacement to her armor. In the *Amiral Baudin* 33 per cent. was absorbed in the same direction. The *Admiral* class of English battle-ships, although the area protected was very small, it was of such thickness that more than 30 per cent. of their displacement went to armor. The new

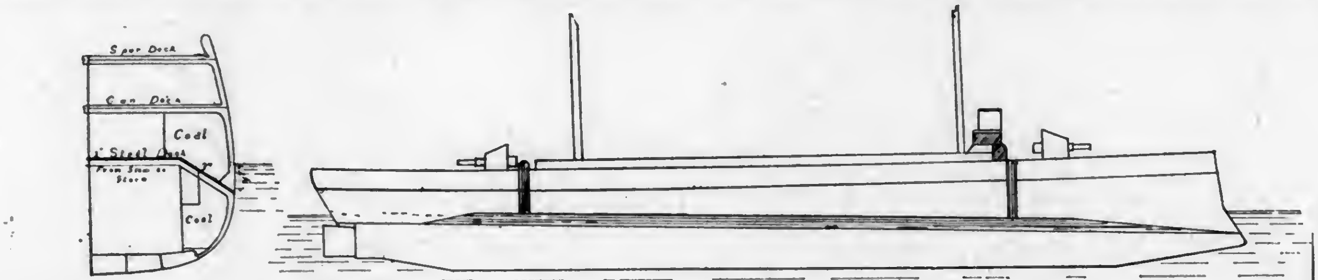


FIG. 7.

except that upon the protective deck, which has a maximum thickness of 6 in. This deck is 18 in. below the water-line amidships, and 6 ft. at the sides. The coal carrying capacity of the *Blake* is phenomenal. This supply is sufficient, it is claimed, to enable her to cruise 15,000 miles at the rate of 10 miles an hour, or, as has been said, her 1,500 tons of coal will take her to Calcutta and back at that rate of speed, without once stopping to replenish her coal bunkers. It is expected that her triple-expansion engines and twin screws will, with forced draft, drive her at a rate of 22 knots, or faster than any war-ship ever yet built.

The partially protected cruisers have usually a displacement of less than 2,000 tons, and the deck protection, which is of the same character as that of the larger cruisers, extends ordinarily only over the vitals of the ship, something more than one-half its length. With this deck and a proper disposition of the coal the machinery is all fairly well protected.

Reference has been made to the employment of cellulose, or wood-armor, to prevent the entrance of water following a shot at or below the water-line. The method of employing this material, in some of the new French cruisers, is shown in fig. 8.

It has been said that the first iron-clad came from the hands of its builders clad in a complete suit of armor. Gradually this suit was curtailed a little here and a little there until in the *Admiral* class of English ships, and the Italian ships of recent construction, little attempt was made except to protect the gun-towers of the heavy guns and the ammunition tubes. If, however, we look at the model

battle-ships will give about 4,500 tons of their 14,000 to armor. The *Dupuy de Lôme*, with her all-over armor, only yields 15 per cent. of her displacement, while the French cruiser *Tage* devotes 14 per cent. of her 7,000 tons to horizontal armor alone. The Italians, in the reconstructed *Re Umberto*, have extended the armor plating

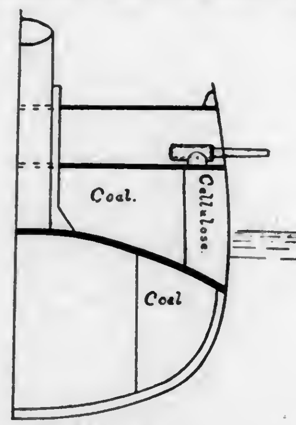


FIG. 8.

from the steel protective deck upwards to the upper deck, giving moderate protection for the secondary battery, and covering two-thirds of the length of the vessel from below the water-line upward.

(TO BE CONTINUED.)

THE SOULEUVRE VIADUCT.

(Condensed from *Le Genie Civil.*)

THE line from Vire to Caen, of which the first section was opened in 1888, and the remainder is under construction, passes through the rough and irregular region known as the Norman *Bocage*, where the undulating nature of the ground and the unequal hardness of the rocks in the hills made the problem of location particularly difficult and interesting. The final location was one selected after a number of preliminary surveys and much consultation. It is the line which was considered not only the least costly, but also the most favorable for traffic, and may be called the hill line, following the general line of the high grounds and not that of the valleys. The most expensive work required for this line was the viaduct here illustrated, and the cost of this, it was considered, was more than balanced by the reduction effected elsewhere by avoiding the deep cuttings and the rock-cutting which would have been required in the valley location.

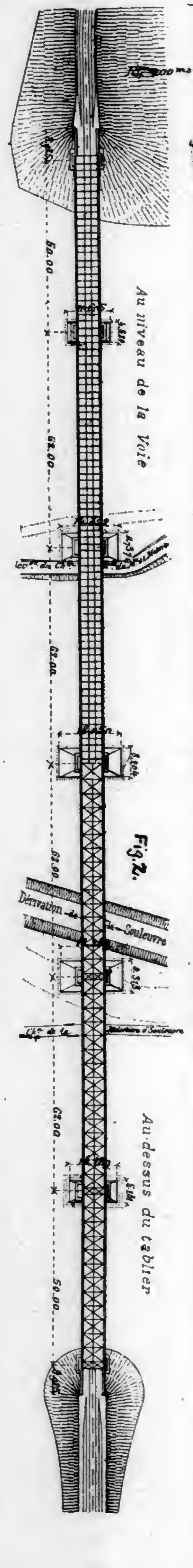
The Souleuvre, a small tributary of the river Vire, runs through a deep valley, the section of which at the point where the new railroad crosses it resembles an irregular trapezoid, the upper and lower sides of which are respectively 400 and 80 m. (1,312 and 262.4 ft.) and the height 70 m. (229.6 ft.). On either side the plateau is nearly level, and the slope toward the valley is very sharp. Under these conditions a choice was offered between a masonry viaduct and a metallic bridge with continuous girders. The first solution was rejected on account of economy, and the plan finally adopted was of a metallic bridge in six spans resting upon masonry piers. The general elevation and the plan of this viaduct are shown in figs. 1 and 2. The total length is 366 m. (1,200.48 ft.). The opening of 348 m. (1,142.44 ft.) between the abutments is divided into two spans of 50 m. (164 ft.), one at each end and four central spans of 62 m. (203.36 ft.) each, measuring from center to center of piers. The bridge is a through bridge, and the level of the rail is 63 m. (206.64 ft.) above the bottom of the valley.

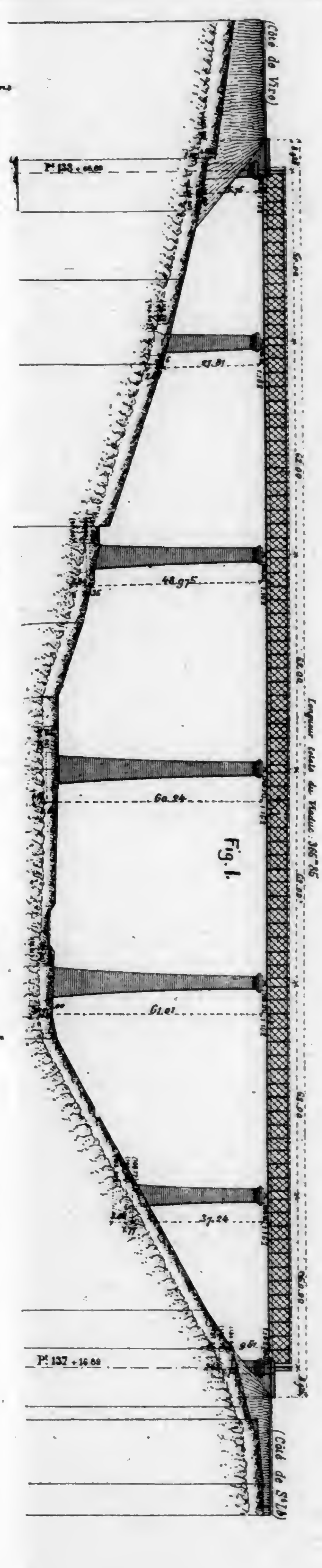
The upper piers are respectively 60.50 m. (198.44 ft.) and 61.47 m. (201.62 ft.) in height above the ground. These are stated to be the highest masonry piers ever built for an iron bridge, for although there are bridges of much greater height, such as the Kinzua and the Kentucky River bridges in America, they are carried upon iron piers.

A through bridge was decided upon because, while a deck bridge would have required a somewhat less height of pier, the excavation at the end of the bridge of a way or channel for launching the span would have required a considerable expense, and, moreover, with the through bridge, the danger from derailment was considered to be less.

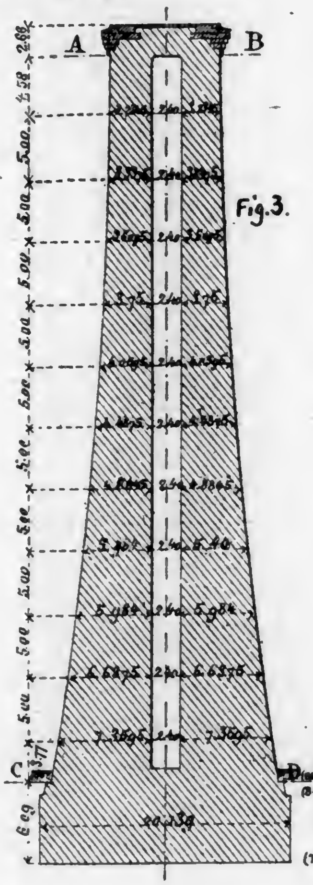
The piers are of rectangular section, and at the top carry a cap of cut stone considerably larger than the upper part of the pier, leaving on either side a space around the bed upon which the span rests. The smallest section of the pier, immediately below the cap, is 8.80 × 4.00 m. (28.86 × 13.12 ft.). In the highest piers the dimensions at the base are more than double this. The batter of the piers is not continuous, but the change in the dimensions is made at intervals of 5 m. (16.40 ft.). The effect is hardly perceptible to the eye, and looking at the piers from the side of the valley the line seems to be continuous and the taper uniform. On account of their exceptional height a large allowance was made in building these piers for resistance to wind-pressure. They were also designed in such a way as to reduce their size to a minimum, at the same time leaving them of such dimensions that the masonry should not be exposed to any undue strains.

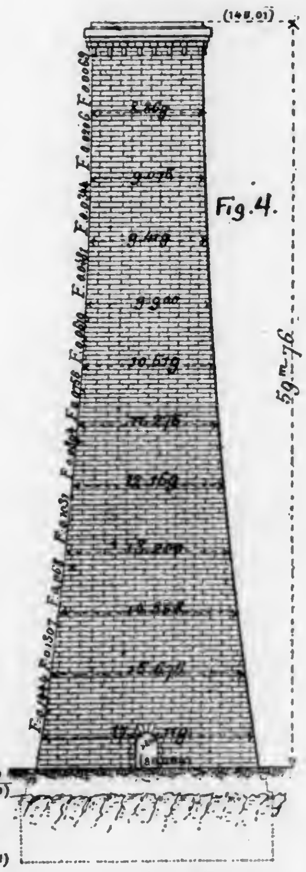
All the piers and both abutments are founded directly upon a schistous rock of very hard nature, but with its strata inclined at an angle of about 45°, and having occasional seams filled with clay, so that it was necessary for some of the piers to excavate for some distance below the surface. The profile adopted for the piers—which is approximately that of a parabola of the second degree with horizontal axis—is continued below the surface for a meter

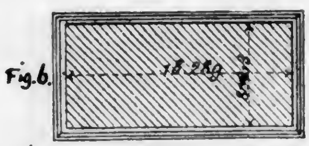




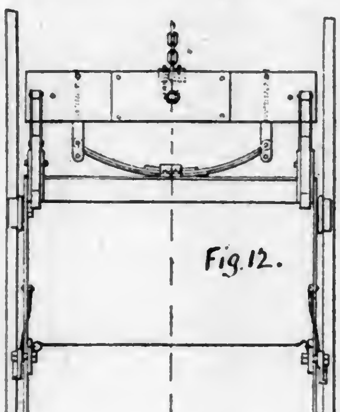
in order to protect the masonry from frost. At this depth the foundation proper begins, which is built up from the rock in steps.

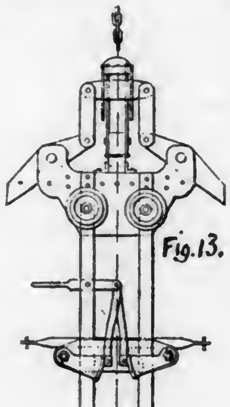






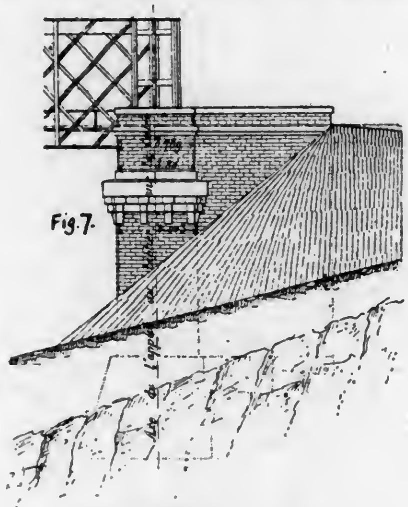
The body of the piers is entirely of rough stone masonry, faced with cut stone having what is known as a rough or rustic finish. The facing stone is of a sort of marble brought from the quarries near Coutances. The caps upon which the bridge rests are of granite from Vire. The

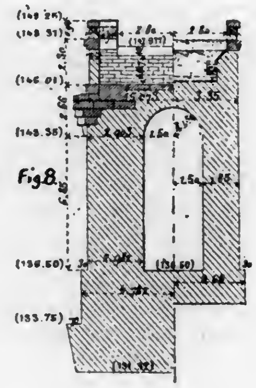


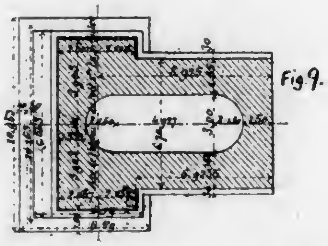


mortar used was made from Teil lime, and of sand which had to be brought some distance, and was procured by breaking up quartz boulders found in the quarries of Mont-Beny.

As most of the material had to be brought from a distance, in order to save as much as possible the cost of transportation, the railroad line was completed to the edge of the valley before work on the viaduct was begun. From the end of this line an inclined road—shown in fig. 10—was constructed by which cars could be sent down into the valley. This inclined road was one meter gauge, and was a temporary line of the Decauville system, and 1,400

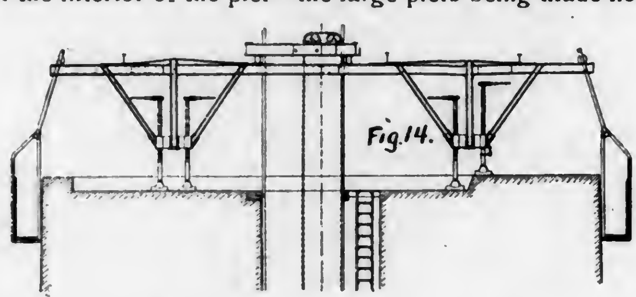






m. (4,952 ft.) long; it was a cable road worked by a stationary engine placed at the top of the hill. The machines for breaking the stone, working the sand, etc., were placed on a small plateau about half-way down the hill, which can also be seen in fig. 10.

One interesting part of the work was the plan adopted for hoisting the material to the top of the piers. Until these piers reached a point about 30 m. (98.40 ft.) above the ground the stone was taken up by an ordinary derrick and steam-hoist. Above that level the hoisting was done in the interior of the pier—the large piers being made hol-



low, as noted hereafter—by a cage somewhat similar to those used in mine shafts for hoisting material; the hoisting rope passing below over the drum of a hoisting engine and above over pulleys supported on a frame. The guides for the cage consist of U-shaped irons, one placed on either

side, and held in place by bolts embedded in the masonry. Figs. 12 and 13 show the hoisting cage used, fig. 12 being a front elevation and fig. 13 a side view. The small wagons containing stone or mortar were run upon this cage at the bottom through an archway left in the side of the pier, and at the top they were rolled from the cage and

Fig. 10.

discharged upon the platform, the wagons being at once returned. The hoist served also for carrying the workmen up and down, but for use in case of accident a wooden ladder was also built up. The cage was provided with safety brakes or clutches, which would at once stop it in case of the breaking of the rope. These safety brakes were automatic, and in case of their failure to work an additional brake was provided, which could be worked by

The interior shaft or well in the center of the piers had a rectangular section of 1.20 × 2.40 m. (3.93 × 7.87 ft.), the corners being rounded. This central shaft left room for the cage and for the wooden ladder provided in case of accident, as noted above. The highest pier is shown in figs. 3, 4, 5, and 6; fig. 3 being a section of the pier, fig. 4 an elevation, fig. 5 a cross-section just under the cap, and

Fig. 11.

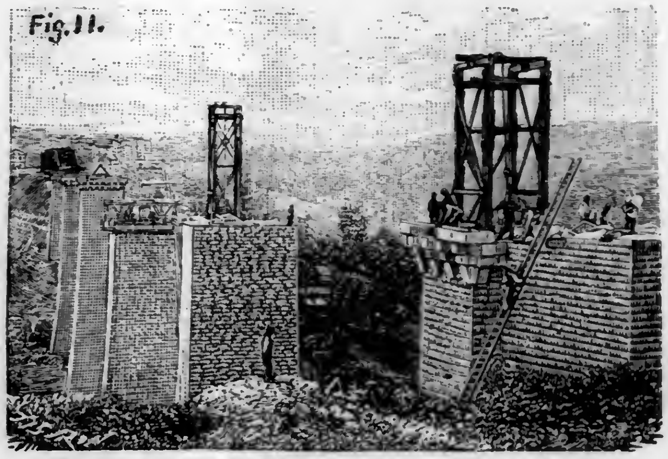


fig. 6 a plan. The other piers were of the same construction in all respects, differing only in height.

The platform at the top, upon which the workmen and material were carried, was a light frame of iron, made in sections for convenience of carriage, and held together by bolts. It rested upon the masonry of the pier by means of four feet, each foot consisting of a pair of hydraulic jacks having a lift of one meter, so that the platform could always be kept level. This platform or false-work is shown in figs. 14 and 15, fig. 14 being an elevation and fig. 15 a plan. It will be seen that by the aid of these jacks the

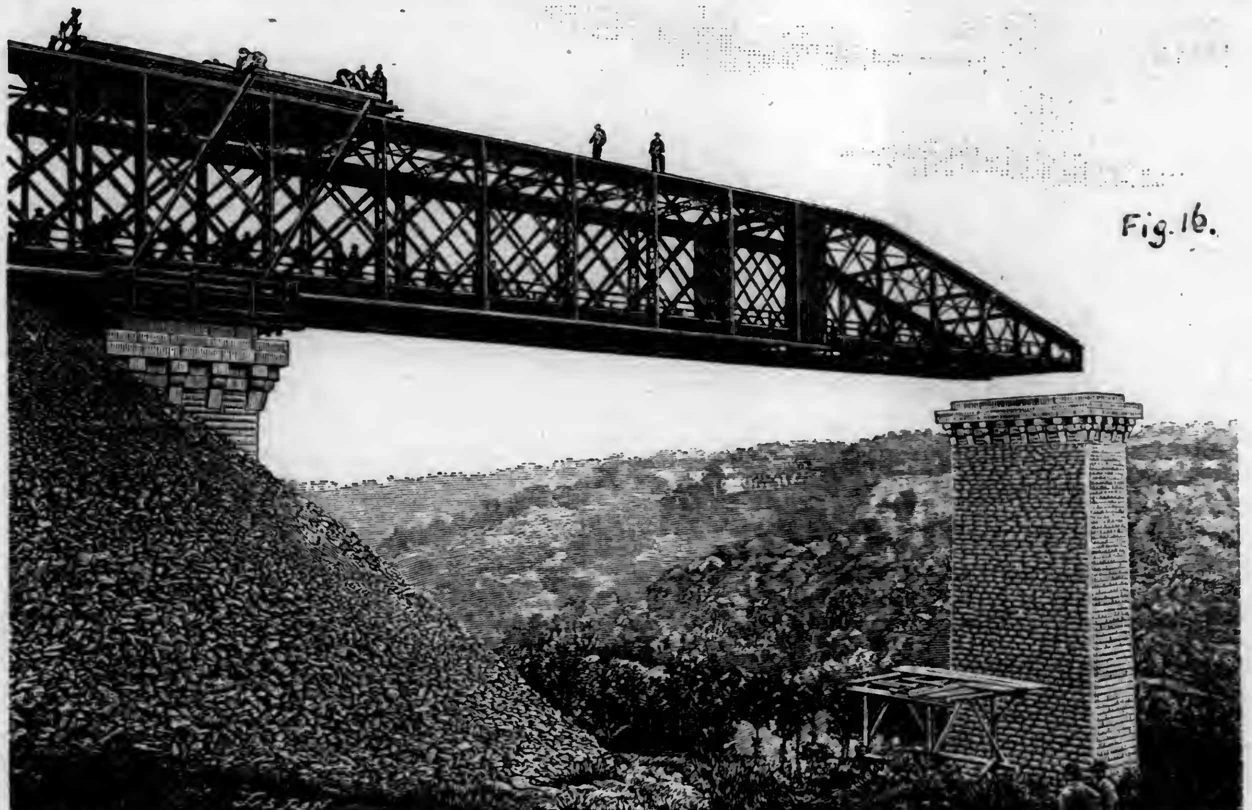


Fig. 16.

hand. As the height of the piers was continually changing, and as the engineer, therefore, could not tell exactly by experience when to stop the cage either at the top or bottom, as in the case of a mine shaft of fixed depth, an electric signal was provided by which the engineer could be notified when to stop and start, and by it the hoisting cage could be stopped at any point.

platform could not only be kept level, but would leave sufficient room for the masons to work underneath it. An awning or cover was provided, which could be used when necessary to protect the workmen from the weather, and a safety railing on the outside to prevent accidents.

The construction of the abutments does not require special mention. Fig. 7 shows an elevation of one of these

abutments, fig. 8 a section, and fig. 9 a plan showing the manner in which the masonry was constructed and the bed or seat upon which the end of the span rested.

Figs. 10 and 11 show two views, one taken from either side of the valley, of the piers while under construction. It will be noted that in addition to the interior shaft a scaffolding or false-work was constructed on one side of each pier. Fig. 16 shows the manner in which the bridge was finally erected, the completed span being built up and riveted together first, and then launched from the abutment to the first pier, and so on.

It may be noted that the pointing of the masonry on the outside of the piers was executed without difficulty, in spite of the great height, after each pier had been completed, by means of a suspended platform upon which two masons at a time worked. These frames was suspended by cables from the cap of the pier, and could be lowered and raised at will by the masons themselves. They were supplied with mortar by a separate hoisting rope.

THE GLOSSOP PNEUMATIC HAMMER.

THE accompanying illustrations show a power-hammer made by the Glossop Pneumatic Power Hammer Company, Birmingham, England. It is of much the same type as the Chenot atmospheric hammer, which was described in the JOURNAL for April, 1889, page 165, an air cylinder

Fig. 1.

being in both substituted for the springs often found in light power hammers.

In the accompanying illustrations fig. 1 shows a small hammer, and fig. 2 a larger hammer with double standards and a separate anvil-block.

The special feature of this hammer is a direct-acting air cylinder, to which a reciprocating motion is given by a connecting-rod and crank, driven by a pulley and belt. The hammer-head is attached to the piston-rod, which hammer-head and the air cylinder move between vertical guides. The front valves of the air cylinder are automatic ; but the valves at the back of the air cylinder are worked and regulated by hand or foot, according to the size of the hammer and the class of work to be done, and are entirely under control. When the belt is on the fast pulley, a vertical reciprocating motion is given to the air cylinder, thus moving the piston, with its rod and hammer-head, up and down. By movement of the treadle or handle, the valves at the back of the air cylinder are operated on and the hammer-head held stationary, although the cylinder continues to run at full speed. At any moment, therefore, by simply moving the treadle or handle, the lightest or heaviest blow can be struck, at the operator's will. The front valves admit sufficient air at each stroke to keep the piston suspended between two cushions of air. The hammer-head receives not only the momentum given to the cylinder by the crank-shaft, but also additional force from the elasticity of the air confined in the cylinder. When the most powerful blows are given, the hammer-head travels twice the distance of the air cylinder at each stroke.

These hammers are made in a number of different sizes, varying from 50 lbs. up to 2,000 lbs. weight of moving parts.

This is a compact and convenient tool for light forging, and may be used in many places where the work is not heavy enough to warrant the establishment of a steam hammer.

Whether this type of hammer presents any advantage over spring hammers of different patterns, such as the Bradley, the Bouhey and others, is probably an open question.

PERFORMANCE OF A DOUBLE-SCREW FERRY-BOAT.

[Papers read before the American Society of Mechanical Engineers, by E. A. Stevens and Professor J. E. Denton.]

I.—THE FERRY-BOAT: BY E. A. STEVENS.

THE first propeller-boat used for ferry purposes was constructed in the first decade of this century by my grandfather, John Stevens, and made a run between Hoboken and Barclay Street, New York, my uncles, John C. Stevens and Robert L. Stevens, acting respectively as pilot and engineer.

The engines of this vessel are at present in the Stevens Institute ; and it is a curious coincidence that she was run over the very route on which the *Bergen* is now serving.

The problem of constructing a screw ferry-boat has been a long-standing one with the Hoboken ferries. Early in the '70's, Mr. Francis B. Stevens, of Hoboken, got up a model and some preliminary drawings for such a vessel. The management, though not prepared for so radical a departure, kept the question before their minds as a possibility. Early in 1885 it became evident that two new boats must soon be built, and the question was raised whether they should be made propeller boats or not. With some reluctance it was decided that there was not sufficient time to mature the necessary plans, as it became evident that the subject needed careful and close study.

The service demanded of a New York ferry-boat calls for some peculiar features of construction.

The weight of the loads carried, both in passengers and teams, as well as the strain caused by the ice, and the danger of collision, all call for a hull of great strength and rigidity. Beyond this, the vessel must have great stability, to resist burying by the head as well as heeling. She must be able in floating ice, and should attain a speed of about 12 miles an hour in service.

The main characteristics of the *Bergen's* model are a full flaring upper body, fine under-water body, with a full water-line, a sharp V-shape midship section, and the peculiar cutting away of the ends to bring the rudders and screw within the perpendicular of the stems.

The shape of the water-lines and upper body were determined by consideration of power in ice and stability.

The midship section, in order to give an unbroken line for the shafting, had to have a certain depth. It was found that with the required displacement the form adopted was about the only practicable one. The experience on the Hoboken Ferry, moreover, had been very favorable to a sharp V section. The older wooden boats, built on a perfect V section, gave excellent results, while of the iron and steel boats, the *Orange* and *Montclair*, which more closely approach that section, gave better results than the other boats, which had a semi-circular section ; and, as far as could be judged, than the West Shore and the Penn-

sylvania Railroad ferry-boats, with straight sides and a flat floor.

The experience on the Hoboken Ferry, with balanced rudders hung under the keel and supported from above, having been very favorable both as regards efficiency, strength, and ease of repair, it was decided to use a rudder as nearly similar to the ones in use as conditions would allow.

The form with the ends of rudder-stock supported in the shoe, appeared most suitable, and the fixed rudder in the bow seemed to promise protection from ice to the forward screw. This arrangement has shown itself perfectly satisfactory in practice.

The question as to motive power presented four alternatives :

1. One engine, driving a line of shaft with universal flexible joints, there being an angle in the shaft on each side of the engine, as proposed by Mr. Cowles.

2. One engine, without such joints, and with a straight shaft, as in the *Bergen*.

3. Two engines, each driving independent shafts at an angle to each other, as in the *St. Ignace*, and I believe in the boats built by Brady.

4. Two engines, either with or without flexible joints in their shafts, driving two propellers at each end, as in the Mersey boats.

This last plan was rejected on account of the lesser protection from ice afforded the screws, and the fear of trouble in riding upon racks, as is often done when entering a slip with a strong wind and tide.

The advantages of the first and third methods were a deeper submersion of the screw and a flatter midship section. The disadvantages were the insecurity of the flexible joints in the first method ; and in the third, the increased cost of construction and operation.

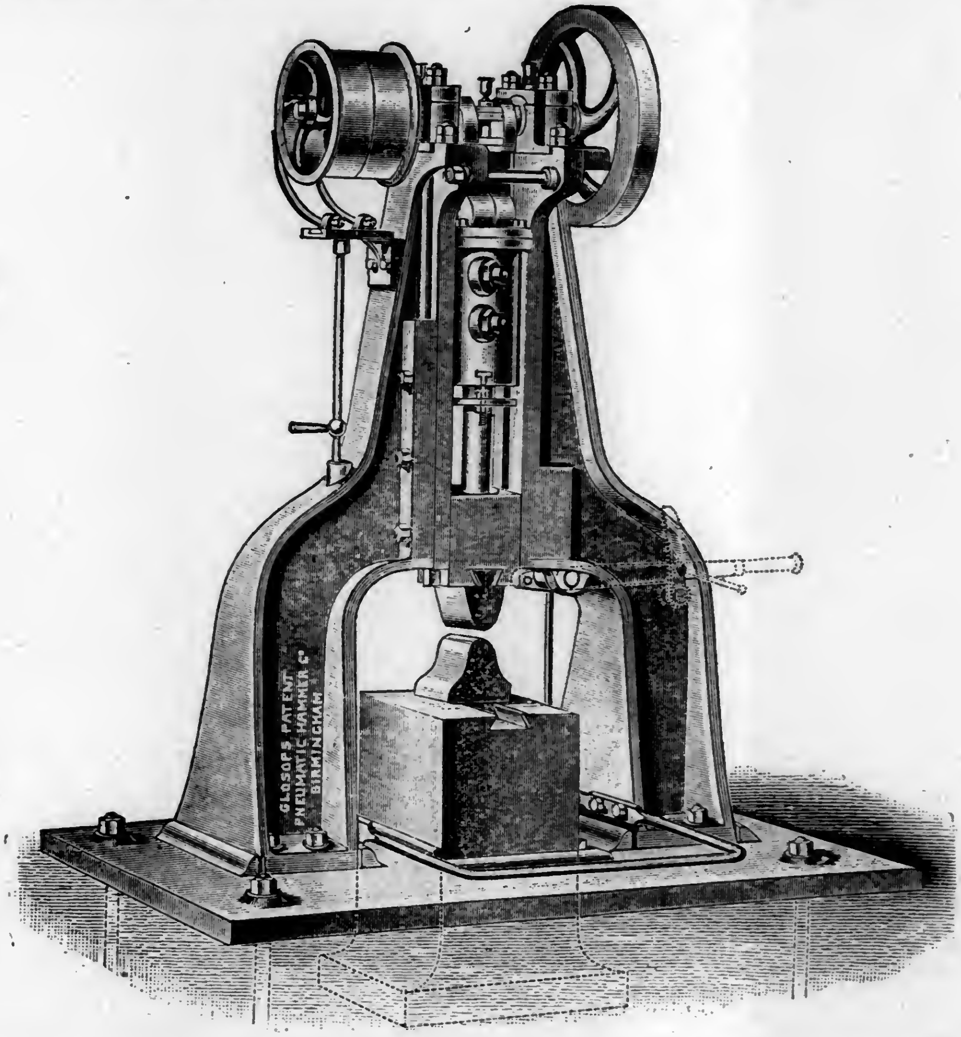
The cost of construction on the plan adopted has shown an advantage in the case of the screw. The hull is slightly more expensive, the engine decidedly less so, with the same power.

The engines and boilers of the *Orange*, 500 H.P., cost about the same as the *Bergen's*, 660 H.P.

I might add here that the *Bergen* is, if anything, more powerful than necessary.

In cost of operation it was found that, in a six weeks' run, the saving in coal would more than pay for the wages of an oiler and the extra lubricators used. Whether an oiler is necessary is doubtful.

Fig. 2.



As to capacity, the following table shows a comparison between the *Bergen*, *Orange*, and *Moonachie* :

	Bergen.	*Orange.*	*Moonachie.*
Date when built	1889.	1887.	1877.
Material of hull	Steel.	Steel.	Wood.
Type of engine	Triple-expansion Propeller.	Low-pressure beam.	Low-pressure beam.
Size of cylinders	18½ in. 27 in. 42 in. × 24 in.	46 in. × 10 ft.	44 in. × 10 ft.
Working pressure	160 lbs.	45 lbs.	30 lbs.
Length on load water-line	200 ft. 0 in.	217 ft. 0 in.	200 ft. 0 in.
Beam " "	32 " 2 "	32 " 0 "	32 " 0 "
Beam over guards	62 " 0 "	62 " 0 "	62 " 0 "
Draft, hull to base line	8 " 10 "	7 " 8 "	8 " 0 "
Displacement to load water-line.	560 tons.	655 tons.	550 tons.
Displacement per in. at l. w. l.	12.6	....	....
Space available for passengers	4,330 sq. ft.	3,791 sq. ft.	3,335 sq. ft.
" " " teams	3,448 " "	3,940 " "	3,380 " "
Number of seats for passengers,	296	254	236

It is to be noted in case of the *Bergen* that the space is more available, especially as regards teams, her team capacity being greater than the *Moonachie's*, and almost equal to the *Orange's*.

A decided advantage in the *Bergen* is the ease with which she can be unloaded, the saving in the crowded hours of travel being very considerable.

In point of handling, the *Bergen* compares very favorably with any ferry-boat on the river. Her greater draft makes her exceptionally steady on her helm, while it is found that she can turn as readily as other boats.

She can stop in a shorter distance notwithstanding her higher speed.

The defects that have been found are not incident to the design, and while there are many departures that will be made in the engine in the next boat built, the hull will be practically unchanged, and no alteration in the engine involving any change in principle has as yet been found advisable.

In closing I would say, that the *Bergen* should be regarded as an experiment in adapting a style of propulsion that has been successfully employed elsewhere to the purposes of a ferry-boat in New York Harbor. Whether use in heavy ice will show any defects that may require modification is as yet an unsettled question ; but we feel full confidence that no more serious trouble than a change in the type of the propellers will be met.

Practically, the *Bergen* is preferred by passengers and pilots alike. While the boat is by no means perfect, she is the best boat we have, and will furnish a type for our future boats.

The engines of the *Bergen* were designed by Mr. J. Shields Wilson, of Philadelphia. A number of engineers gave us advice and encouraged us by their confidence in the plan of building such a boat. Among the latter I may mention Mr. Frank Kirby, of Detroit, and Messrs. Herman Winter and Andrew Fletcher, of New York.

II.—RESULTS OF EXPERIMENTS : BY PROFESSOR J. E. DENTON.

The objects of the experiments undertaken were to determine the relative economy of the *Bergen*, as compared to the best type of paddle-wheel ferry-boat having the common style of overhead beam engine, a jet condenser, and drop-return flue boilers. The paddle boat selected for this purpose was the *Orange*, one of a pair of steel boats designed in 1887, by Mr. Francis B. Stevens, and representing the best modern example of its class of ferry-boats. The programme carried out was as follows :

1. The steam consumption, boiler evaporation, horse-power, and speed were determined for each boat during 14 hours of regular ferry service.

2. Each was run to Newburg and return, a distance of 120 miles, without stoppage, and the steam consumption per horse-power determined at the maximum capacity of the boilers. Also, the evaporative economy of the boilers, starting with new wood-fires, was determined during an interval of 14 hours, and the speed was measured by an estimate of the probable velocity of tides, and a log whose correction co-efficient was approximately known.

3. The speed of the *Bergen* was determined at the maximum horse-power for which the engines were designed, by opposite runs over a 1-mile course, after allowing the boiler pressure to accumulate above the average pressure which the boilers can maintain for more than a few minutes.

4. One of the screws of the *Bergen* was removed, and the power and speed determined by runs over a 2-mile course, first with the single screw pushing and then with it pulling the boat at equal speeds of revolution of the engine.

The principal conclusions drawn from the experiments are as follows :

1. The steam used per horse-power for all purposes is 25 lbs. per hour for the beam engine, and 22 lbs. for the triple engine, under their average conditions of ferry service ; but the consumption of the *Bergen's* main engine is only 18.3 lbs. per hour per H.P., the direct-acting steam feed and circulating pumps, etc., consuming about 3.7 lbs. per indicated horse-power.

2. The steam consumption of both engines does not sensibly differ while in intermittent ferry service, from that found during continuous working of the engines.

3. The economy of the drop-return flue boiler of the *Orange* is practically the same as the locomotive type in the *Bergen*, both boilers evaporating on the average about 8½ lbs. of water per lb. of bituminous coal, under ordinary working conditions, thus making the consumption of coal per hour per H.P. about 2.9 for the beam engine, 2.6 lbs. for the *Bergen*, for all purposes, and 2.15 lbs. for main engines alone.

4. The speed of the boats under all conditions is practically in accordance with the law of cubes, and by the application of this law it appears that for a still-water speed of 12.6 statute miles an hour the following statements are practically true : The paddle-wheel boat would require 642 H.P., and would make 24½ revolutions per minute with a slip of 26 per cent.

The screw boat, using double screws, would require 680 H.P., an engine speed of 145 revolutions, and the slip would be 12½ per cent.

The screw boat, using one screw at the stern, would require 584 H.P., 152 revolutions per minute, and the slip would be 18 per cent.

The screw boat, using one screw at the bow, would require 692 H.P., 163 revolutions per minute, and the slip would be 18 per cent., but the recoil upon the hull of the water which the screw acts upon would make the apparent slip about 22 per cent.

5. The screw at the bow, using the same horse-power as the screw at the stern for equal revolutions, propels the boat slower than the screw at the stern by an amount practically equal to the equivalent of the extra resistance due to the increase of the velocity of the boat by an amount equal to the velocity of slip of the screw.

6. By calculations based upon the accepted relations between the slip of the screw and the velocity of a boat, it appears that, in order for the double screws to produce the same speed as a single screw of the same diameter at the stern, the slip of the latter must be to the former in the ratio of 18:11, and therefore the cause of the extra power consumed by the two screws, as compared with the one screw, is the fact that the slips are as 18:12.6, instead of 18:11. To alter this ratio of slip, the diameter of the two screws must be greater than that of the one screw.

A TRIPLE-EXPANSION MARINE ENGINE.

THE accompanying illustrations (from the *Steamship*) show a triple-expansion engine built for the steamship *Ivy* by the firm of Westgarth, English & Company, of Middlesboro, England, which is of a neat and compact type. Fig. 1 is a front view and fig. 2 a rear view of the engine showing its general construction ; figs. 3, 4, and 5 show the details of the cylinders and valves.

The engine is of the ordinary inverted type, with three cranks, each cylinder having a separate direct-acting valve-gear. The condenser forms a part of the main framing, the back columns being cast upon it. These columns are of cast-iron, and fitted with separate slide-bars of cast-iron for the cross-heads. The after column is used as an exhaust pipe for the steam from the low-pressure cylinder, and the intermediate column contains the air-vessels for the pumps. The front portion of the frame consists of three circular cast-iron columns, the center one carrying the reversing-gear. The bed-plate is a strong box casting, to which the condenser and the columns are bolted. It carries five main bearings fitted with adjustable cast-iron bushes lined with white metal for carrying the shaft. It is secured to the engine-seat and the ship's frame with heavy bolts.

The cylinders are 16½ in., 26 in., and 44 in. in diameter and 33 in. stroke. The high-pressure cylinder has a piston valve, the intermediate cylinder an ordinary slide-valve, and the low-pressure cylinder an ordinary single-ported valve. The valve-gear is a link motion with double-bar link. The eccentrics are of cast-iron, with cast steel straps. The reversing-gear is worked by hand. The ordinary working pressure carried is 160 lbs.

The pistons of the high-pressure and intermediate cylinders are fitted with packing rings and springs of the Buckley pattern ; that of the low-pressure with ordinary metallic rings. The piston-rods are 4 in. in diameter and the connecting-rods are 6 ft. in length between centers.

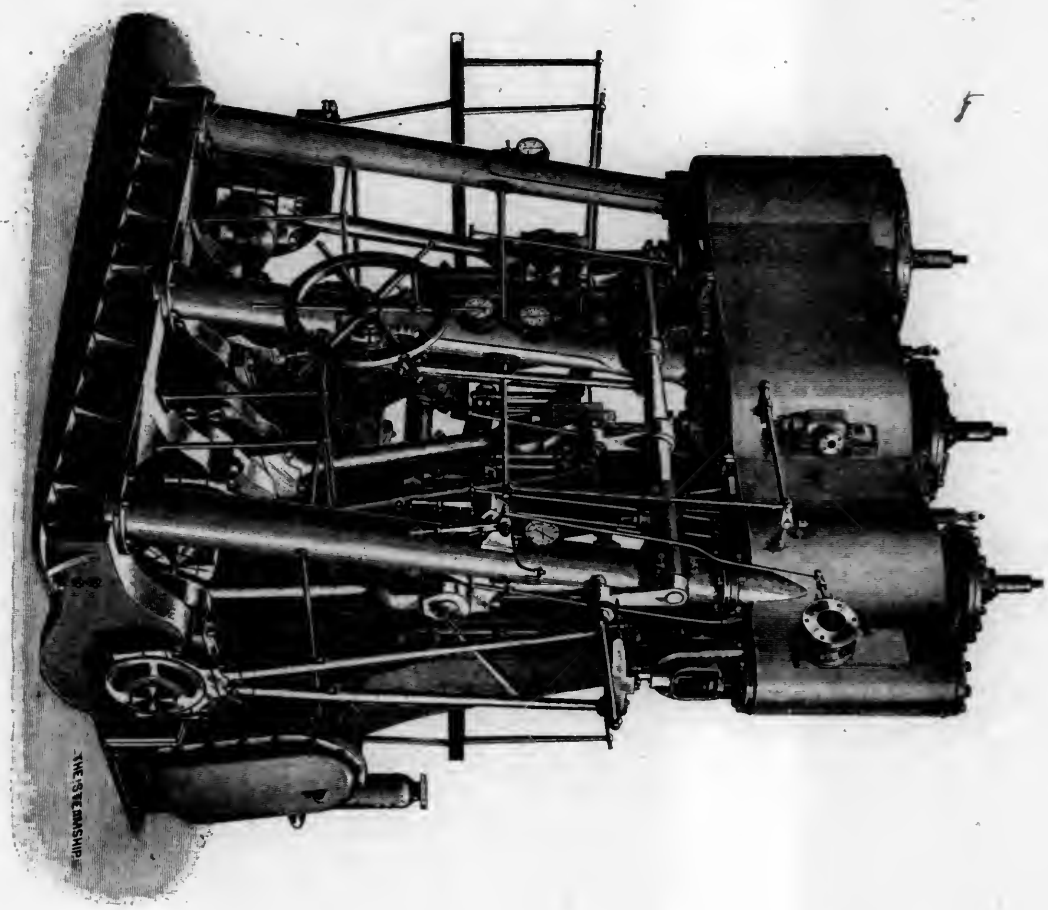


Fig. 1.

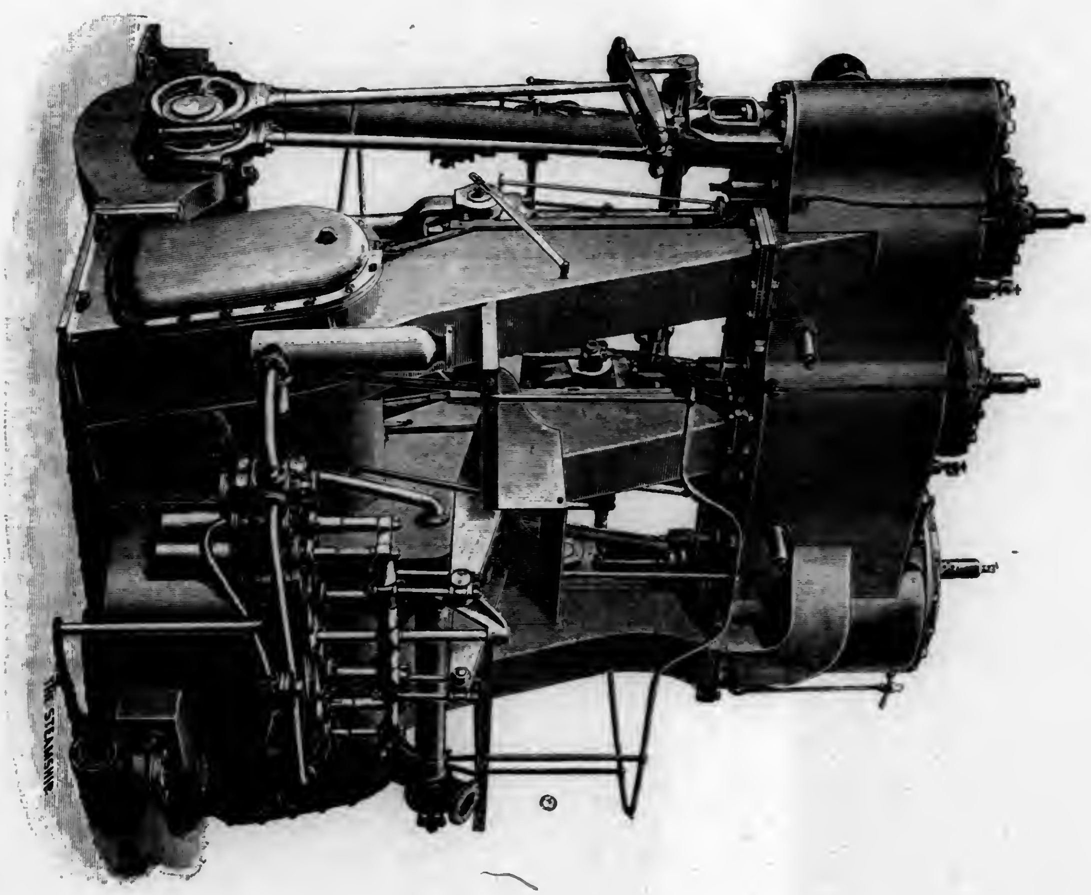


Fig 2.

TRIPLE-EXPANSION MARINE ENGINE, STEAMSHIP "IVY."

Escape valves are fitted to both ends of each cylinder and to the intermediate and low-pressure receivers ; these valves are spring-loaded, with proper adjusting screws. ⅝ in. outside diameter, packed with wood ferrules, and have a cooling surface of about 800 sq. ft. The circulating pump is single-acting, 11 in. in diameter and 18 in. stroke.

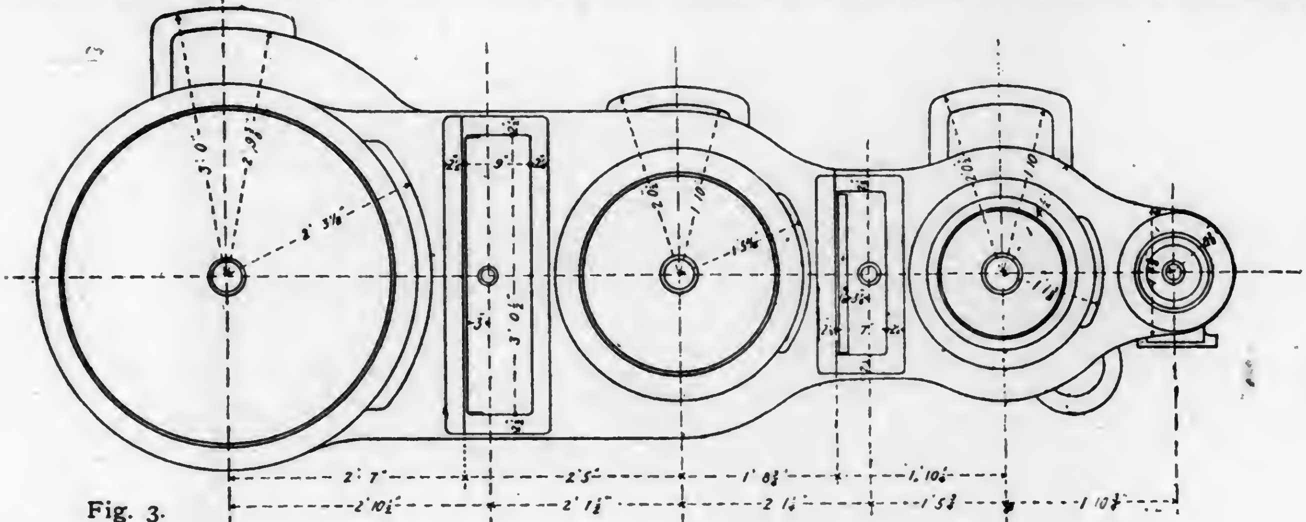


Fig. 3.

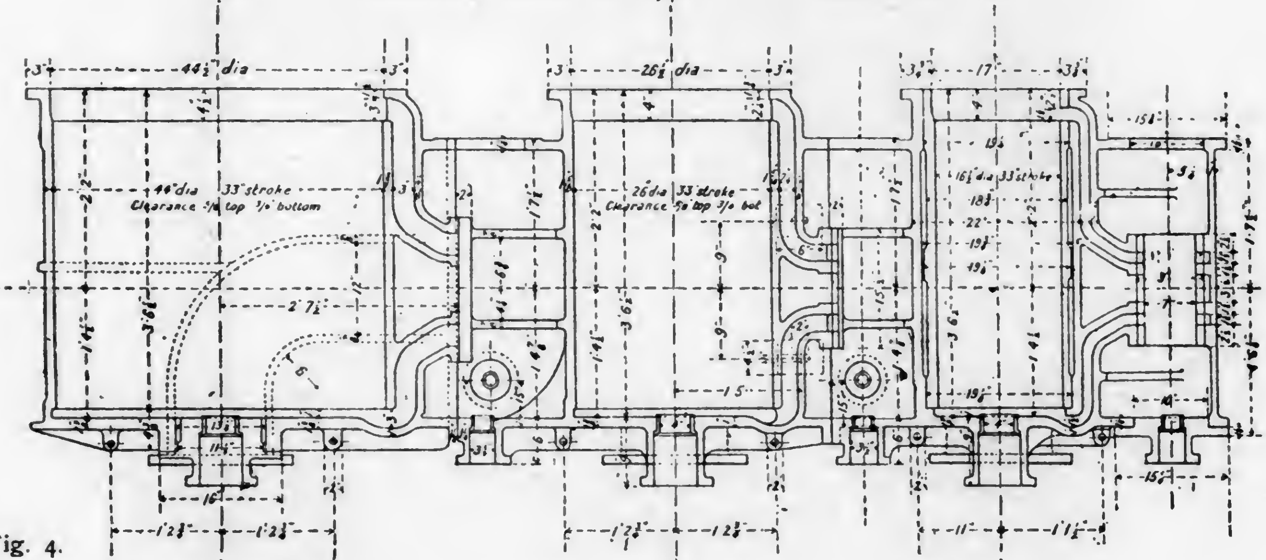


Fig. 4.

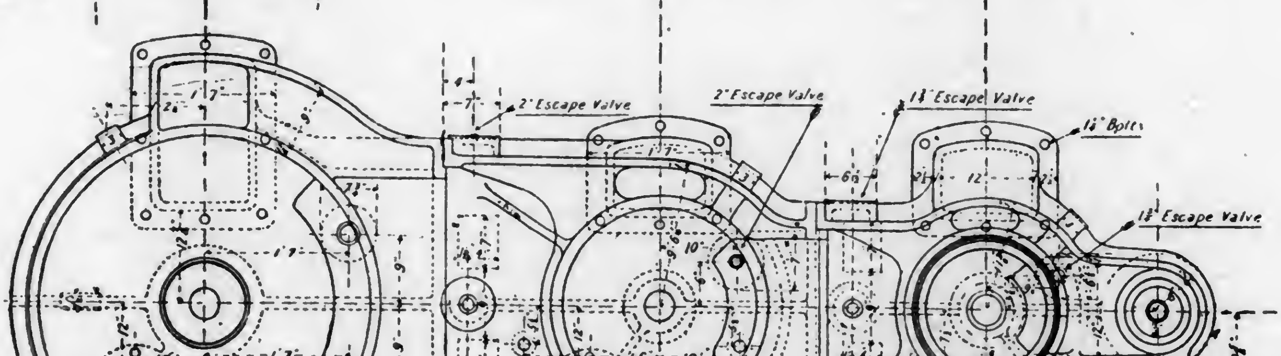


Fig. 5.

An auxiliary hand-valve, which can be worked from the starting platform, is fitted to the intermediate cylinder.

The condenser, as already stated, forms a part of the frame. It is a surface condenser fitted with brass tube-plates 1⅛ in. thick, with a cast-iron supporting plate 1 in. thick in the center of the tubes. These tubes are of brass, The barrel, bucket, and valves are of brass. The air-vessel for this pump, as already stated, is in one of the back columns.

The air pump is single-acting, 13 in. in diameter and 18 in. stroke, and is of brass and fitted with the necessary valves. The air vessel for this pump is also contained in

one of the back columns. There are two single-acting feed pumps, 2 in. in diameter and 18 in. stroke, and also the necessary donkey, ballast, and bilge pumps.

The crank-shaft, of forged iron, is $8\frac{1}{2}$ in. in diameter; the crank-pins are $8\frac{1}{2}$ in. in diameter and 9 in. long, and are set at an angle of 120° with each other, as shown in the engraving. The propeller shaft is $8\frac{1}{2}$ in. in diameter and connected to the crank-shaft by the usual couplings. The engine works a four-bladed screw of the usual pattern. Figs. 1 and 2 show very well the general arrangement and pattern of the engines, while figs. 3, 4, and 5 show the arrangement and dimensions of the cylinders and valves so well that no further description seems to be needed.

HORATIO ALLEN.

(*Continued from page* 86.)

In September of 1829 Mr. Allen became the Chief Engineer of the South Carolina Railroad. On his recommendation the gauge of the road was made 5 ft. Later the question of the gauge of the Erie road was referred to him as Consulting Engineer of that line. He advised that it also be made 5 ft. It was a great misfortune that his advice was not followed in both cases, and that the gauge for all American railroads was not made 5 ft. The extra width of $3\frac{1}{2}$ in. would now be an immense advantage in the construction of both cars and locomotives. As the weight, size and capacity of these has grown the value of this $3\frac{1}{2}$ in. of space between the rails has increased in about the same ratio.

At that early date the South Carolina Railroad Company had to decide whether the motive power of the road should be horses or locomotives. In a report made to the Company in November, 1829, Mr. Allen presented an estimate of the cost of transportation by horse-power and by locomotive power. The estimate of cost of locomotive power was based on facts obtained on the Stockton & Darlington Railroad. In his pamphlet, "The Railroad Era," Mr. Allen said:

The result of that comparison was in favor of locomotive power, and the report contained a decided recommendation that locomotive power should be the power to be used on the South Carolina Railroad. But the basis of that official act was not the simple estimate resting on the facts as they existed on the Stockton & Darlington Railroad, but, as was stated in the report, was on the broad ground that in the future there was no reason to expect any material improvement in the breed of horses, while in my judgment the man was not living who knew what the breed of locomotives was to place at command.

This report was submitted to a full meeting of the Board, and the decision was unanimous to adopt locomotives as the tractive power on the road, and Mr. Allen added, "it was the first action of this kind by any corporate body in the world."

The South Carolina Railroad when first constructed consisted of timber rails or stringers 6×12 in., on which iron bars $2\frac{1}{2} \times \frac{1}{2}$ in. were spiked. When the question of motive power came up for consideration it was essential that the weight per wheel should not be greater than the structure described could safely bear. The load per wheel, therefore, had to be limited, and it also seemed to be highly important to place as great a quantity of power within one machine as possible. In another communication made May 16, 1831, to the President and Directors of the road Mr. Allen discussed the general subject of steam transportation, and especially the subject of boiler capacity of locomotives, and then said:

When we come to consider the application of locomotives to wooden roads there are circumstances which call for attention, and a particular adaptation of arrangement to them. As the same amount of attendance and repairs attend engines of the various powers within the range that can be employed on railroads, it becomes a highly important object to place as great a quantity of power within one machine as possible. And this is more peculiarly the case on a road where the great and most difficult sources of expense are the attendance and repairs, while the fuel is comparatively of little consequence. As on every road there exists a limit of weight to be placed on each pair of wheels, and as on wooden roads this limit is much less than on an iron one, it becomes a still more interesting inquiry to ascertain by what means we may increase the quantity of power without exceeding the limit. On the Liverpool & Manchester road they appear practically to be limited to three tons on each pair of wheels, though some accounts state this to be too high, with their velocity, for the permanent benefit of the road. On a wooden road, where only $\frac{1}{2}$-in. iron is made use of, I would put the limit at $1\frac{1}{2}$ tons per pair of wheels.

If, therefore, there can be no arrangements whereby this disadvantageous relation may be provided for, it is evident that to convey the same quantity of goods or transport the same number of passengers, we must incur twice the expense of attendance, twice the amount of repair, and twice the liability to accident. In fact, more than twice, since in doubling the weight of the engine we are able to appropriate a greater proportion of the increased weight to steam-generating purposes.

The arrangement which I would propose to effect so desirable an object would be, as the limit exists in the quantity on each point of support, to increase the number of supports, and thus distribute the weight over a greater surface. I would therefore place the engine on six or eight wheels, and limit the weight to $1\frac{1}{2}$ tons to each pair.

There arise two objections to this arrangement, from the inequalities in the line of support; the one vertical, the other horizontal.

If three or four wheels were united on a side to the same rigid straight line, and the road had irregularities in its surface, there would arise great and injurious strains to the structure, from the wheels not being able to adapt themselves to the irregularities.

This difficulty may be completely obviated by giving the weight to be supported but two points of support on each side, and making these points the centers of motion of the pairs of wheels.

This arrangement will evidently adapt itself with as much ease and simplicity to all vertical irregularities, as is the case with two wagons connected together.

As to the change of direction horizontally, as in the entrance of turnouts and the passage of curves, a very simple adjustment will relieve the arrangement from all difficulty. If we connect the frame with the cross-piece only at the center, and by a horizontal point, the two sets of wheels will thereby be enabled to pass all curvatures with the facility of two simple wagons connected in the ordinary manner.

No attempt has yet been made to accommodate the locomotive carriage to the passage of curvatures, by providing the means of changing the parallelism of the axles, and giving them the relative inclination that the radius of curvature requires.

As a result of this communication the Company authorized the construction of several "steam carriages" on this plan. Mr. Allen accordingly left Charleston early in the summer of 1831 for the North, and contracted with the West Point Foundry for the construction of the engines. The first one built and put in operation was the *South Carolina*. She was received at Charleston in January, 1832, and was put in operation in February, 1832. Three others were also constructed and put in operation before the end of 1832.

On October 1, 1834, a patent was granted to Ross Winans, of Baltimore, for eight-wheeled cars with two trucks. In his specification he described his invention as follows:

I construct two bearing carriages, each with four wheels, which are to sustain the body of the passenger or other car, by placing one of them at or near each end of it, in a way to be presently described. The two wheels on either side of these carriages are to be placed very near to each other; the spaces between their flanches need be no greater than is necessary to prevent their contact with each other.

* * * * * * * * *

The body of the passenger, or other car, I make of double the ordinary length of those which run on four wheels, and capable of carrying double their load.

This body I place so as to rest its whole weight upon two upper bolsters of the two before-mentioned bearing carriages or running gear.

The Newcastle & Frenchtown Turnpike & Railroad Company built or used cars containing Winans' improvements, but denied the validity of his patent. Hence, in 1838, Winans brought his first suit at law against that Company. This was the beginning of 20 years of litigation with the railroads of the country, a brief history of

which was written by Mr. William Whiting, of Boston, counsel for some of the defendants, and published in 1860 with the title "Twenty Years' War against the Railroads." Of this litigation Mr. Whiting said:

It was at one time a question of millions, to be assured by a verdict of a jury—not indeed in a single suit, but as the result of enforcing the plaintiff's claim wherever railroads were in use and the courts of the United States had jurisdiction. A single verdict, sustained by the court, would enable that result to be easily reached. Stimulated by such hopes and fears, the litigation has been conducted with a corresponding perseverance, labor and talent. From Maine to Maryland, through a period of 18 years, in various courts of law and equity, against a great number of railroad companies and against other defendants, before juries of the country and juries of the city, before not less than six different judges of the courts of the United States, and with all the talent and learning that abundant means and a liberal hand could supply, with a pertinacity of purpose rarely equalled, the plaintiff has pressed his claims.

The case was finally carried to the Supreme Court in Washington and was heard in 1858, and a final decision was given in favor of the railroads and against Winans. In closing his account of this remarkable trial Mr. Whiting said:

Thus, after *twenty years* of controversy—the commencement of a large number of actions at law and in equity against the railroads, the actual trial of eight cases—the recovery, by Mr. Winans, of two verdicts sustaining his patent—the disagreement of the jury in three trials, the finding of one verdict at Canandaigua against him, the expenditure, on both sides, of not less than $200,000, and the authoritative settlement of the suit at Washington in favor of the railroads, ends this remarkable chapter in the history of litigation.

In these trials the testimony of Mr. Allen, and the eight-wheeled engines which he built in 1831, became very important evidence, and in an opinion given by Judge Nelson he said: "The decided preponderance of the evidence is, that this steam carriage embraces all the elements, arrangements, and organization to be found in the cars manufactured by the defendant."

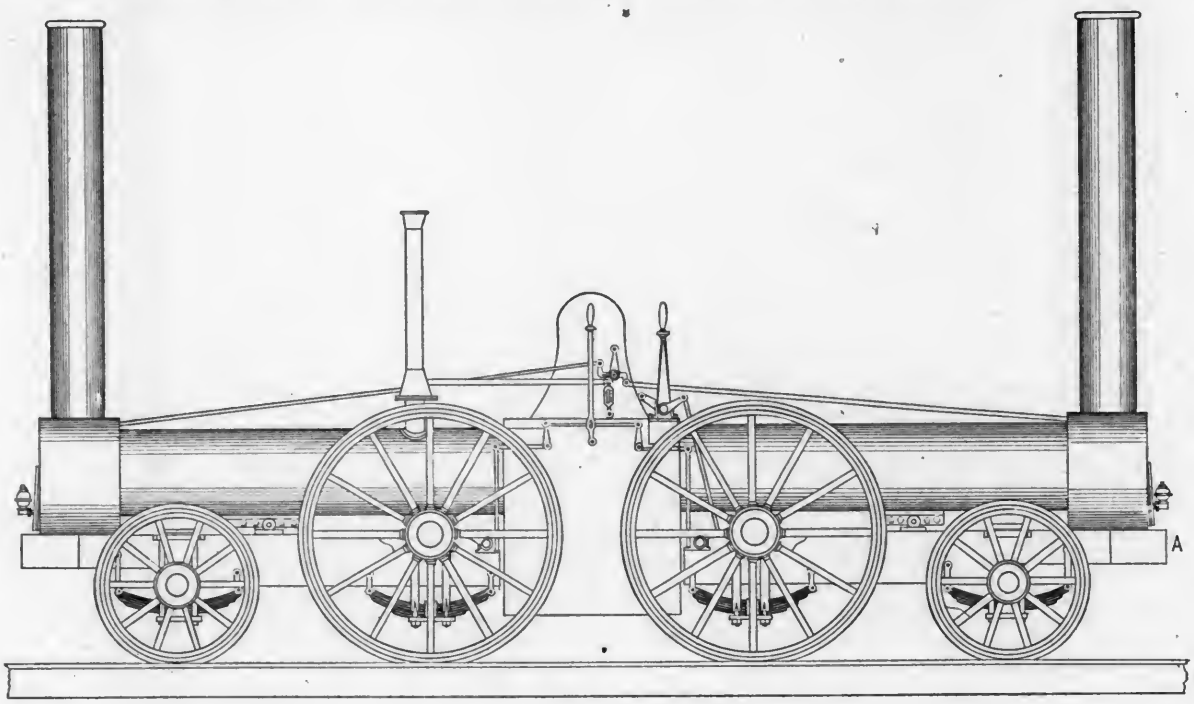


Fig. 2.

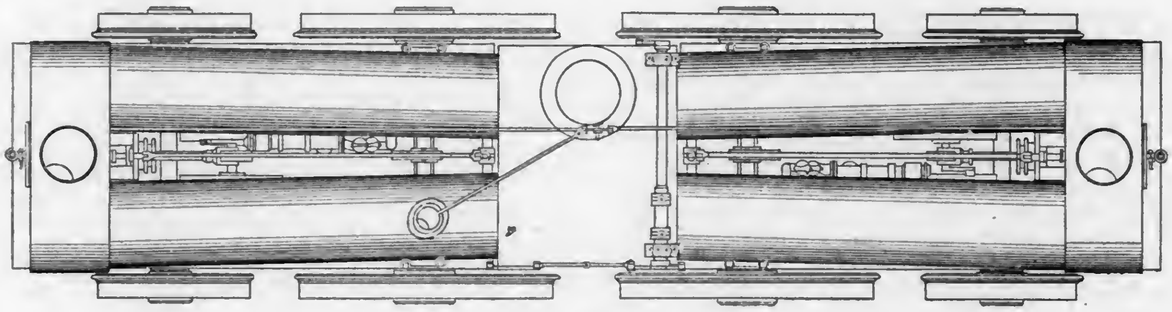


Fig. 3.

DOUBLE-TRUCK LOCOMOTIVE.

DESIGNED BY HORATIO ALLEN IN 1830, AND BUILT AT THE WEST POINT FOUNDRY, COLD SPRING, N. Y., IN 1831, FOR THE SOUTH CAROLINA RAILROAD.

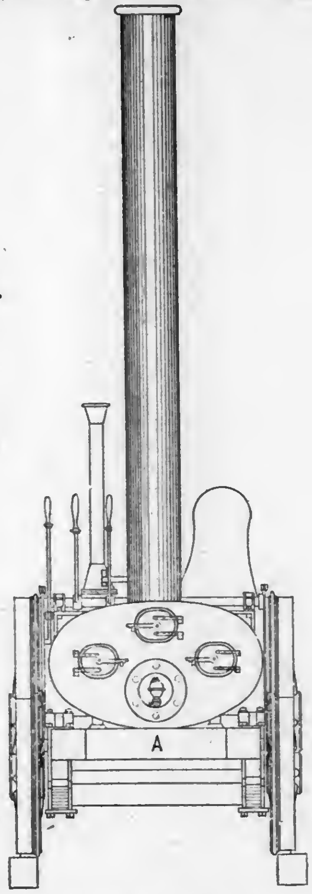
The invention or first use of the truck on locomotives has been a subject of dispute for a long time. This seems to be a proper occasion for summing up the evidence with reference thereto.

The use of a truck in connection with steam carriages is distinctly suggested in the English patent granted to William and Edward W. Chapman, dated December 30, 1812. In this it is said:

Fig. VIII. (not given here) shows a carriage of six wheels for the engine, which may rest equably, or nearly so, on each of its wheels, and move freely round the curves or past the angles of a railway. 1, 1, the fore pair of wheels, are, as usual on railways, fixed to the body of the carriage; 2, 2, and 3, 3, the other two pair, are fixed (on axles parallel to each other) to a

separate frame, over which the body of the carriage should be so poised, as that two-thirds of its weight should lie over the central point of the four wheels, where the pivot 4 is placed, and the remaining third over the axis 1, 1. The two-thirds weight of the carriage should rest on conical wheels or rollers, bearing upon the curved plates *c, c*, so as to admit the ledges of the wheels, or those of the way, to guide them on its curves or past its angles, by forcing the transom or frame to turn on the

Fig. 4.



pivot, and thus arrange the wheels to the course of the way, similarly to the carriage of a coal-wagon. And if the weight of the locomotive engine should require eight wheels, it is only requisite to substitute in place of the axis 1, 1, a transom, such as described (laying the weight equably upon both) and then similarly to two coal-wagons attached together, the whole four pair of wheels will arrange themselves to the curves of the railway.

There is no evidence to show that the Chapman plan was ever put into practice.

It was also brought out in the Winans litigation that in the early part of 1830, long timbers were carried on the Baltimore & Ohio Railroad on two four-wheeled cars, on which bolsters were placed, with a round pin passing down through a plate attached to the truck; string-pieces from 20 to 45 ft. long were then placed on the bolsters. Each of the two four-wheeled cars were thus enabled to adjust themselves to the vertical inequalities and horizontal curvature of the track. It was argued that this embodied substantially the principles of the double-truck car.

In the printed testimony in the Winans litigation Mr. Allen's and other concurring evidence is given at great length. Lithographed copies of the original plans and drawings of the double-truck engines designed by Mr. Allen, for the South Carolina Railroad, are appended to the volume of printed "Evidence for Respondents" in this case, and the engravings given herewith (figs. 2–5) are accurate copies made on a smaller scale from these lithographs. He testified that the plans for the eight-wheeled engines were drawn by C. E. Detmold, his assistant, in the close of 1830 or the early part of 1831.

Mr. Detmold testified as follows:

Before the drawings were commenced the principles of the eight-wheel double-trucks were fully developed and explained to me by Mr. Allen, so that I then clearly understood the subject of the construction and operation of the eight-wheel double-truck railroad cars, as well as I now do. The adoption of the eight-wheel engines became necessary from the fact that the Charleston Railroad was constructed of wooden rails with a light flat iron bar, the rails being supported on sleepers resting upon piles, at a distance of 6½ ft. apart. The four-wheel engines acted very injuriously upon this light structure, because the greater part of the weight of the locomotive was at one end, and therefore the slightest irregularity in the road caused the engine to operate like a heavy hammer upon the rails, which injured both rails and engine, and produced a very unsteady and unsafe motion. The object of Mr. Allen was to make such improvements in the running gear as to obviate these difficulties. This was done by placing two swiveling trucks under the long body of the engine. The body was very much longer than that of the ordinary four-wheel engine.

* * * * * * * *

The object was to obtain a small amount of pressure on each wheel, while the body carried was increased in length and weight, and to give the two trucks a proper action to conform to the curves and other inequalities of the road, and, at the same time, to cause the body of the steam carriage to run more smoothly or steadily on the road than the four-wheel steam carriages previously in use; and also to transport more freight and passengers, and run with more ease, safety, and economy, both as to the train and to the road.

Mr. Horatio Allen, in the winter of 1830 and 1831, made some of the drawings himself, and the drawing marked *G* (fig. 5), and signed by me, is one of the drawings showing parts of the steam carriage.

Mr. Detmold testified further that:

"During the winter of 1830 and 1831, under the direction of Mr. Allen, I made and assisted Mr. Allen in making drawings of the double-truck steam carriages. A portion of the original drawings is now before me . . . and a copy thereof, which I believe to be correct, is annexed to the deposition of Horatio Allen, in the present case."* He emphasized his evidence to another interrogatory by answering: "I am absolutely certain as to the date at which I assisted in making said drawings."

As already related the first of the engines was built from these drawings in 1831, and was put in operation in January, 1832.

The same volume of testimony from which such liberal quotations have already been made contains that of the late John B. Jervis, who claimed to have invented the locomotive truck, in which he says:

My attention has been particularly directed to the subject of the arrangement of the wheels of locomotives and cars to facilitate the running of locomotives and cars on curves; my attention was very early directed to that subject. It was a subject on which I had often thought a good deal, but made no experiments *until* 1831. In 1831 and early in 1832 I was very much engaged in devising some means by which four wheels could be substituted for two as the leading wheels of the locomotive, and finally prepared a plan by which the forward end of a locomotive was supported by a sort of independent carriage consisting of four wheels. Those wheels were placed near to each other and working under the main frame of the engine, which rested mainly on the outside timber on friction rollers, supported in its lateral position on the frame of the independent carriage by a center pin, and this independent carriage being a substitute for the two wheels formerly used. . . . A locomotive was made on that plan under my direction by the West Point Foundry Association in 1832. I think it was called the *Experiment.* The locomotive was put on the Mohawk & Hudson Railroad in the autumn of 1832.

In another deposition Mr. Jervis said:

I invented a new plan of frame, with a bearing carriage, for a locomotive engine, *in the latter part of the year* 1831, for the use of the Mohawk & Hudson Railroad, which was constructed and put on the road in the season of 1832.

* * * * * * * *

The engine had six wheels; on one pair, the driving-wheels, rested in the usual way, one end of the frame of the engine; the other end of the engine rested on the frame of a four-wheel car or truck, so arranged that by means of a center pin passing through a transom beam, the upper frame on which the engine rested could follow the guide of the lower frame, without necessarily being parallel with it. Friction rollers were placed on the lower or truck-frame, to support the engine-frame, and allow the truck-frame to move freely under it. By this means a long frame for an engine could be and is supported near its

* The engravings, figs. 2–5, have been made from copies of these drawings.

end, which provides for the most steady motion of the machine, and by the separate truck to guide, it passes on curves with all the facility of a short-geared car.

From the evidence quoted it will be seen that the drawings for Mr. Allen's double-truck engine were made during the latter part of 1830 and the beginning of 1831. In his report to the President and Directors of the South Carolina Railroad Company, dated May 16, 1831, he says: "I would therefore place the engine on *six* or eight wheels." As his report contemplated and advised the use of the truck, and as a two-wheeled truck was not known at that time, obviously what must have been intended was the arrangement of a four-wheeled truck at one end of the en-

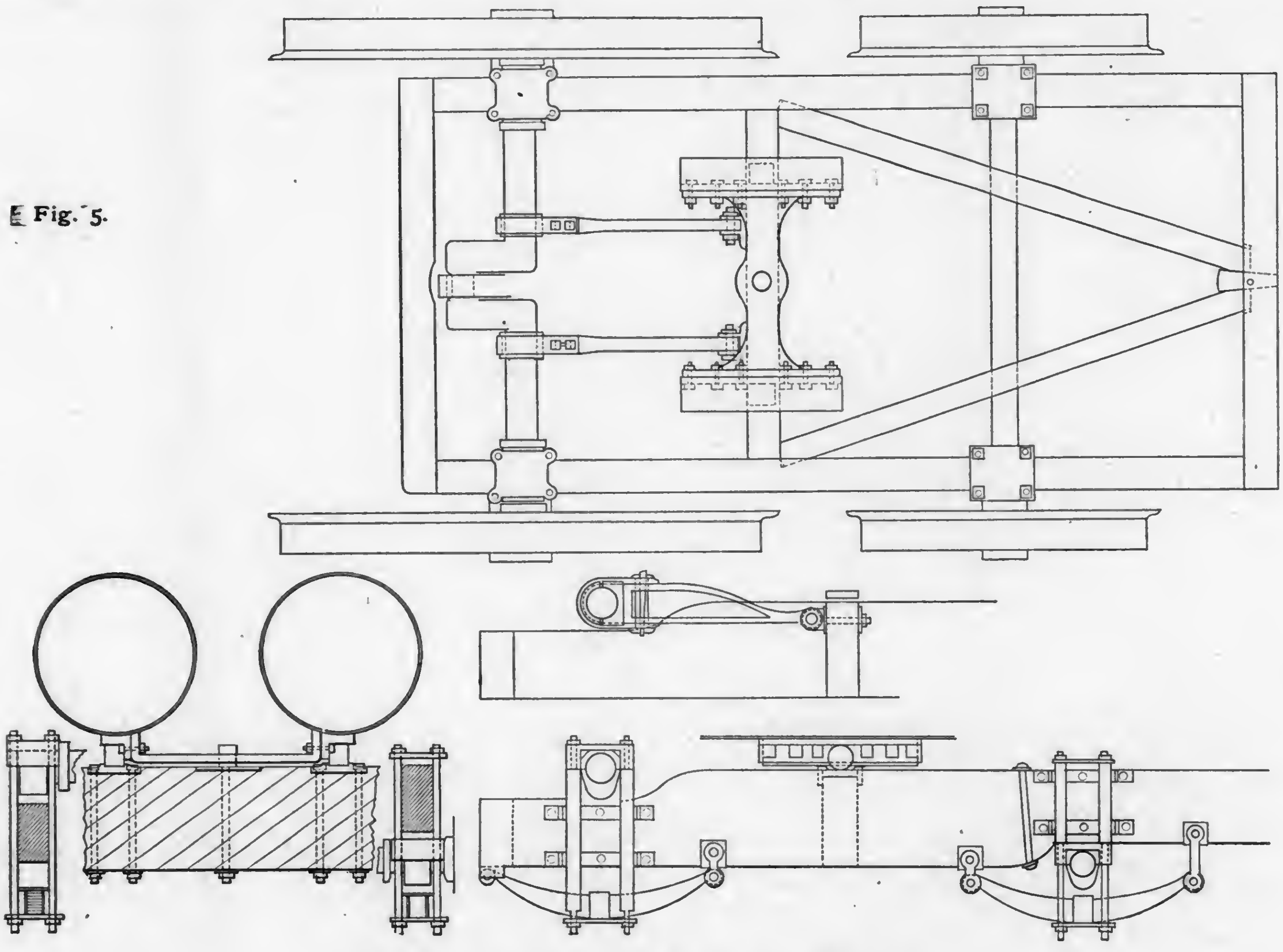
Q. How long was the six-wheel engine used, as near as you can recollect?

A. My recollection is, that it was in use until I left the road; I have no definite knowledge about it.

This testimony was given in 1853.

It is thus clear that Mr. Allen matured his plans for a double-truck engine in the latter part of 1830, and suggested a single-truck engine in his report of May 16, 1831. Mr. Jervis testified that he invented "a new plan of frame with a bearing carriage" in the latter part of 1831. Mr. Allen's first double-truck engine was put in operation in February, 1832. Mr. Jervis's single-truck engine was put in use early in September, 1832.

Fig. 5.



DETAILS OF DOUBLE-TRUCK LOCOMOTIVE.

DESIGNED BY HORATIO ALLEN IN 1830.

gine, and a pair of driving wheels attached to the main frame at the other.

In testifying in the Winans case the following questions were asked and the answers were given by Mr. Allen:

Q. You say that you became satisfied that it would be necessary to place the steam carriages on six or eight wheels, and that you devised the means of adapting the carriage for six or eight wheels; will you state what adaptation was made for six wheels?

A. By using one truck with four wheels, as already described in the eight-wheel arrangement, and connecting the other pair of wheels and their axle with the main frame of the locomotive.

Q. Did you construct a locomotive, or more than one, to be used on said road, with six wheels?

A. I altered one four-wheel English engine to a six-wheel arrangement.

Q. When?

A. I don't know.

Q. Try and recollect the year.

A. I can't recollect; I can make an inference about the time it must have been.

Mr. Jervis before his death wrote a letter in which he claimed that the plan of applying a truck to a locomotive which he introduced is the one which has since been universally used, whereas that which was devised by Mr. Allen, and adopted in the construction of the engines for the South Carolina Railroad was impracticable, and until the plan was revived by Mr. Fairlie it had fallen into entire disuse. While this is true, nevertheless the records show that, so far as priority of use is concerned, that to Mr. Allen belongs the credit of having first applied the truck to locomotives, and of having suggested its use as it was afterward applied by Mr. Jervis. Whether the alterations to the English locomotive, which Mr. Allen testified under oath he had changed to a six-wheeled engine, with a truck, were made before or after Mr. Jervis had the *Experiment* built, will now probably never be known.

In this connection it may be well to examine another bit of testimony bearing upon this question of the invention of the truck. In a paper by Mr. Vernon Smith, on "The Development of the Locomotive," read before the Canadian Society of Civil Engineers, in 1889, he says:

As the invention of the truck is claimed almost universally for America, and as it has subsequently become a prominent feature in American locomotives, it may be well to place on record a few facts that at least go to prove that the Newcastle shops had something to do with the invention.

Then, in referring to the old drawings in Stephenson's office in Newcastle, the Author says :

The next number, still 1831, is No. 42, ordered by the Saratoga & Schenectady Railway, an engine with 9 in. × 14 in. cylinders, one pair of 4 ft. 5 in. driving-wheels, and a truck with 4 wheels 2 ft. 8 in. diameter.

The third edition of Wood's "Treatise on Railroads," published in 1838, contains a tabular statement of the Dimensions of Locomotive Engines manufactured by R. Stephenson & Company. In this No. 42, for the Saratoga & Schenectady Railroad, is given, but it is distinctly said that it had two driving and *two supporting wheels.* As the two-wheeled truck was unknown at that time, obviously either Mr. Wood, who wrote in 1838, or Mr. Vernon, whose paper is dated last year, is wrong.

In giving his evidence Mr. Allen described the engines for the South Carolina Railroad as follows :

I gave each four wheels, at either end of the engine, an independent frame or truck. I connected the center of that frame or truck with the boiler of the locomotive by a center pin, and I supported each end of the boiler by rollers, resting on the sides of the truck about midway between the pair of wheels commonly called side-bearings. This arrangement allowed each truck or frame to move horizontally around the pin and allowed each frame to move vertically around the point at which the boiler rested upon that frame or truck.

Four of the wheels were 5 ft. high, and four, I think, were 3 ft. ; the cylinder of the engine was attached to the boilers. The frames or trucks were covered by the boilers ; by frame I mean the truck ; there was no independent frame ; the boilers constituted the frame. The draw-bar was connected to the truck. The connecting-rod was attached to the crank on main axle, with ball-joints, to allow the trucks to swivel and conform to the curves of the road.

It will be seen from the engravings that the fire-box of the engine illustrated was in the middle of the boiler, and that it had two barrels at each end which extended each way from the fire-box. The tubes are not shown in the cross-section which forms part of fig. 5. That they were multitubular boilers is known by the fact that Mr. Allen informed the writer that the steam-blast was not used on the engines, and that consequently the lamp-black from the resinous pine-wood which was used for fuel filled up the tubes. The fact that the steam-blast was not used also accounts for the high chimney shown in the engravings. The difference in the height indicated in figs. 2 and 4 is due probably to the arrangement of the original drawings on the sheet of paper, which did not leave room enough for the upper part of the chimneys of fig. 2.

There was one cylinder only to each truck. The cylinders were attached to the smoke-box and not to the truck frame. This made the ball-joint (which is not shown in the drawings) necessary to enable the truck to swivel in relation to the boiler and cylinders. If each crank happened to stop on a dead-center the engines were hard to start, and it was said that a judicious use of a fence-rail was sometimes required when this occurred.

In giving his testimony, Mr. Detmold said, of the working of these engines :

So far as the running gear was concerned, they all answered admirably the purposes for which they were built, and had the advantages over the former four-wheel engines, of distributing the weight of the locomotive over a larger surface of rails, and over more points of support, and by the double swiveling-trucks, that of conforming to all the irregularities and curvatures of the roads, and of far greater evenness and steadiness of motion, when running at high speed, and saving injury to the rails and engines by avoiding the hammering I have mentioned. After they had been running some years the difficulty of making sufficient steam became such, that the engines were superseded, but not owing to any defect in the running gear.

The drawings of these engines were obviously imperfect in many respects, but they are all that is left as a record of the construction of these remarkable machines. They show how, at that early date, Mr. Allen anticipated what have since been recognized as essential principles in the construction of locomotives and the operation of railroads. These are, 1st vertical, and 2d lateral flexibility of wheelbase, and 3d the distribution of weight of the locomotive on more points and over a greater surface of the road than was possible with the engines in use previous to 1830. These results, it will be observed, are a consequence of the adoption of the swiveling-truck in locomotive construction, which was devised by Mr. Allen in 1830, and which he constructed in 1831 and put in practice in 1832.

Furthermore, as Judge Nelson remarked in giving an opinion in the Winans case, these engines "embraced all the elements, arrangements and organization to be found in cars with two four-wheeled trucks." It was the early adoption of swiveling-trucks for both locomotives and cars in this country which has so materially "differentiated" American railroad practice from that in other countries, and to Mr. Allen belongs the credit of having had the prescience to see, and the courage to put in practice, what are now recognized as essential principles in railroad construction. With the light and experience of 60 years to guide us, it is now easy to see how very close these early engines of Mr. Allen came to being a most brilliant success. If the driving-axles had been attached to frames fastened to the fire-box, and if the two pairs of small wheels only had been connected to the truck-frames, and the cranks had then been placed at right angles to each other, and the driving-wheels coupled together, the engines would have achieved immortality.

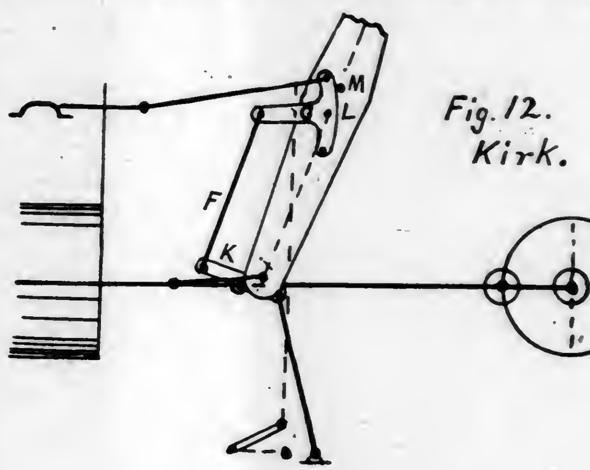
(TO BE CONTINUED.)

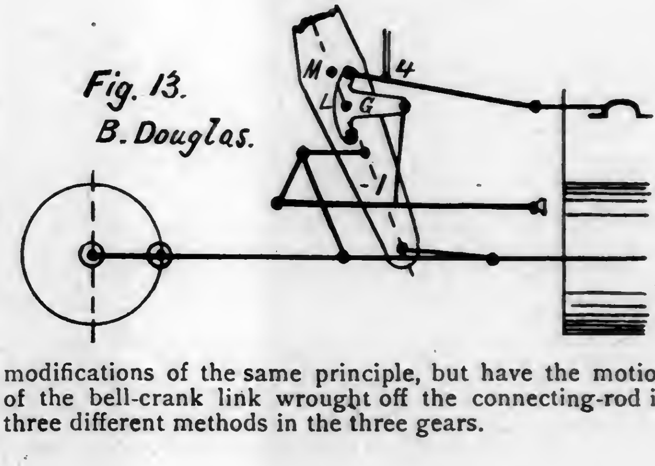
RADIAL VALVE GEARS.

(Paper read before the Hull Institute of Engineers and Naval Architects, by J. R. Smith, Engineer.)

(*Concluded from page 62.*)

KIRK's gear, fitted in the steamship *Australasian* and other ocean steamers, Patent No. 4,135, of 1882, and two of Bryce Douglas's gears, Patent No. 4,958, of 1884, are





modifications of the same principle, but have the motion of the bell-crank link wrought off the connecting-rod in three different methods in the three gears.

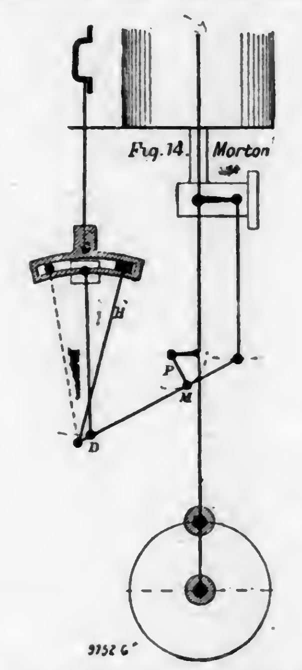
Fig. 12 shows Kirk's and fig. 13 shows one of Bryce Douglas's' gear. In Kirk's gear we have the first introduction of the ingenious method of getting the motion of the valves lap + lead from the piston-rod crosshead through the oscillation of the bell-crank center *L*, this being placed a proportionate distance from the air-pump lever center *M*, thus producing when in neutral gear a motion of the valve equal to lap + lead from the crosshead, as in the Walschaert gear, the port opening being obtained from the vibration of the bell-crank link *G*, which wrought off the connecting-rod by rod *F* connected to compensating link *K*, which, with the previous examples of Brown and Joy, and of Morton's, yet to be brought before you, is the fourth style of correcting the error due to working off connecting-rod.

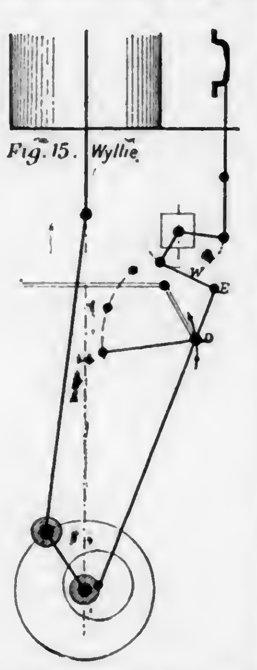
Kirk claims: "The combination of parts forming an improved valve motion, the essential feature of which is the imparting of motion derived from the connecting-rod through a compensating lever and radius-rod so as to lock a curved link centered on a pin, having a motion derived from the piston-rod, substantially as hereinbefore described."

Bryce Douglas claims: "In combination with the lever *I* worked by the piston-rod, and the bell-crank pivoted on *I*; the system of toggle links and their connections, whereby a rocking motion is imparted to *A*, suitable for working slide valves."

In Wyllie's gear, No. 14,783, of 1884, you will see from fig. 15, and in the sliding-block gear (not illustrated), the same adaptation of Hackworth's gear, in both cases with the addition of a compensation-link *W*, introduced to bring the angular motion into a vertical motion at the valve-rod. This compensating link *W* is an essential feature in this gear, as it corrects the unequal travel of valve and does away with the double-port openings on one side. A great many steamers engined by Richardson, of Hartlepool, have been fitted with Wyllie's gear, one of which, the *Santiago* of Hull, has now been working for three years with good results.

Wyllie claims: "The combination of parts forming my improved valve motion, consisting of an eccentric with its



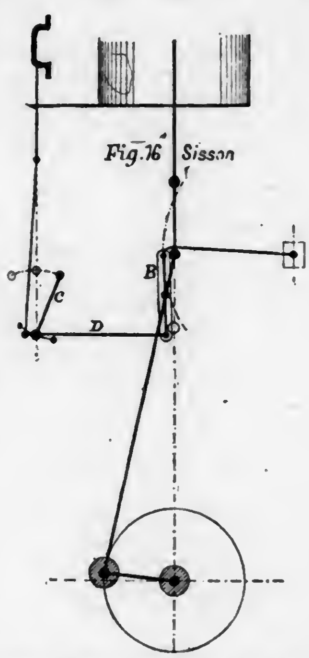


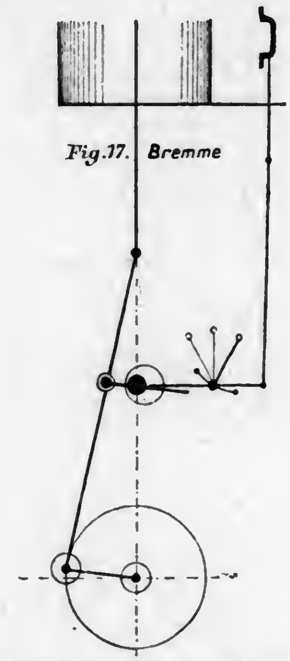
rod placed other than at right angles to the line of motion of the valve and guided in the arc of a circle by a compensating link to a lever through which the movements are transmitted to the valve, so that the said link has such a compensating action as to give equal port opening and cut-off at each end of the valve, in the manner described and illustrated."

In Jack's gear, No. 4,167, of 1885, we have accomplished, by the introduction of an extra swing-link, what Hackworth did by his slide-bars—viz., the fulcrum-pin *D* constrained to travel in a straight line. Fig. 19 is a diagram of the same, where it will be observed that fulcrum-pin *D* swings not only from point *C*, but also from point *J*, the neutralized action constraining *D* to move in a straight instead of a curved line.

It is strange that Jack has not applied it to a lever of the second order as well, as he only claims: "In the gear for operating the valves of motive-power engines, the mounting of the eccentric-rod upon a pin, at from one-third to one-fourth of the distance between the center of *H* and of the eccentric, the same being combined with a parallel motion constructed and operating as described."

Sisson, in 1885, in his Patent No. 6,254, brought out gear of the same class as Joy's, with the compensating





lever differently arranged. Fig. 16 illustrates one style which looks very much like Joy's gear, wrought by Kirk's connecting-rod motion, and so it is a very good gear; but there is not one new feature in the arrangement illustrated, which is a combination of the essential parts of Kirk's and Joy's gears. Sisson claims: "In the valve-gear of a steam-engine, the combination of a link *B*, pivoted to the connecting-rod of a radius-rod *C*, and of a lever *D* connected to the valve-rod of the engine, the lever being pivoted about a center movable to and fro along a path, the direction of which may be made variable," etc.

Fig. 18 shows two of the many arrangements of Swan gear, No. 6,254, of 1885. This is a modified and simplified Walschaert gear, when wrought by an eccentric—No. 1 side of illustration—and a modified and simplified Kirk's gear when wrought off connecting-rod—No. 2 side of illustration; inasmuch as in both of these gears the lap motion was wrought from piston-rod and the port opening was wrought off eccentric or connecting-rod. Now Swan accomplishes both of these motions by the one motion of his eccentric-rod, or the one motion of his vibrating lever. That this is so will be easily seen if we look at the No. 1 illustration, where you will see that the motion of eccentric-rod *C* swinging on a link *F* produces two motions, the first an oscillating motion of bell-crank link *H*, the second an up-and-down motion of the neutral center of this same bell-crank link. Now if we throw rod *E* into neutral position, we neutralize the first of these motions and only move the valve its lap + lead. The same applies to motion off connecting-rod, where it will be observed Swan has copied the essential part of Joy's patent compensating attachment to connecting-rod.

Swan claims: "The use of a reversing link carried freely upon a lever, both link and lever having their motions derived either from a single eccentric or from a single attachment to connecting-rod or single attachment to crank. The new construction of parts (none of which are new separately) worked from a single eccentric or connecting-rod or crank, substantially as described and illustrated."

According to date we should have mentioned Morton's gear (No. 149, of 1882) much earlier, but have reserved it

till now, as it introduces us to a distinct class in the manner in which expansion and reversion are accomplished. This gear, which has come much to the front of late, we illustrate in fig. 14, from which you will observe that when rod *H* is in line with valve-rod, and so gear is in neutral position, the valve will only move lap + lead, but by shifting top end of rod *H* along inverted quadrant *G*, we get the extra travel of valve required for port opening, and accord-

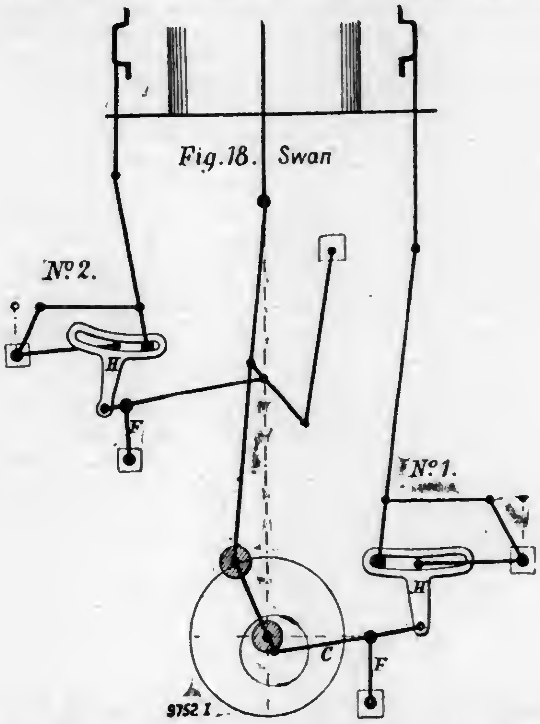
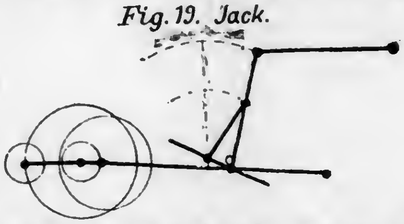


Fig. 18. Swan

ing as rod *H* is on either side of quadrant center we have ahead or astern positions. This gear corrects more perfectly than Brown's or Joy's gears, the error arising from working off connecting-rod, previously mentioned. We referred to the important part *B* played in Brown's gear, also point *J* in Joy's gear, and so in this gear the point *M* plays the same important part, forming the basis of Morton's improvements. The radiating spanner *P* connects vibrating lever to connecting-rod and causes movable point *M* to follow an oval path whose major axis has become a segment of a circle, having a radius equal to the length of vibrating lever. While speaking on these essential points, lettered by the first letter of each patentee's name, we would say that in each of them, by shifting these special points, you can underdo or overdo the effects aimed at. For example, in fig. 7, if you shift *J* in Joy's gear nearer

Fig. 19. Jack.



or further from *R*, you give earlier or later steam top or bottom; the same points, therefore, in Brown's, Kirk's and Morton's have to be particularly watched in overhauling. While in Morton's gear the position of the end of the rod *H* in the quadrant is the means of expansion and reversion, all this is accomplished without either swing link or working sliding-block, so this gear combines all the good points of Joy's gear with the good points of the Walschaert gear, and gives an equal and regular steam distribution. It has been fitted in the Inman, Allan, Donaldson, Clan, City, and other ocean line steamers, giving the utmost satisfaction.

Fig. 19*a* shows Henderson's modification of Hackworth's gear inverted, and as fitted by D. & W. Henderson to some of their Anchor Line steamers, with very satisfactory results; the sliding-block works on two guide-bars, and wears remarkably well.

In No. 7,886, of 1886, Bremme took out a patent for working a shaft other than the crank-shaft by means of a novel connection to connecting-rod. This we illustrate in fig. 17, where you will see that the swivelling arm attached to connecting-rod causes the small eccentric shaft to make one revolution in one complete sweep of connecting-rod. I think I may say few practical engineers will adopt this

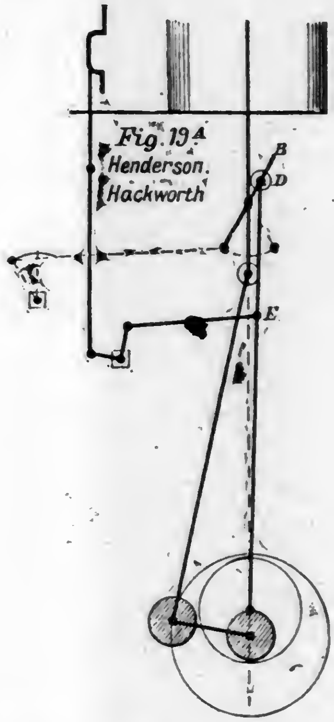


Fig. 19A. Henderson. Hackworth

roundabout way of doing what Joy, Kirk, Morton, and others accomplished in a much simpler and more mechanical way.

Fig. 20 shows Pringle & Arrol's gear, which is wrought by a single eccentric fixed opposite the crank, and reversion and expansion are accomplished by shifting eccentric strap about 30° on either side of neutral line. We illustrate this as the only example we know of, of a modification of Englemann's gear, previously mentioned.

Before concluding our list of valve-gears, we would observe that in a theoretically perfect slide-valve gear the motion would require to be a series of jerks to give a quick and full steam admission, then a period of rest, then a quick cut-off, then another period of rest, and then a quick exhaust opening; and all this should be accomplished with

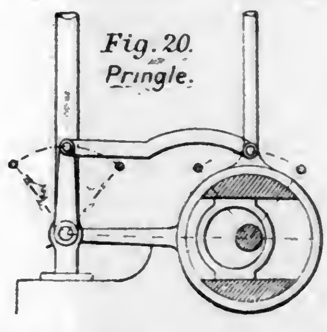


Fig. 20. Pringle.

the same gear with which expansion and reversion are done. A cam-gear working separate steam and exhaust grid-valves can accomplish the first part of these requirements, and I would mention that this was attempted by Robertson, of Glasgow, who, about 1870, took out a patent for working separate steam and exhaust grid-valves by a groove in a revolving disk, and the complete revolution of this groove moved a projecting roller on the end of a lever, producing a motion exactly the same as a cam motion. The Allan mail steamer *Caspian* had her first surface-condenser engines fitted with this gear, which was reversed by a spiral sleeve. They were economical in coal, but the

noise and action of the valve-gear put you in mind of the shuttle-throw of a power loom.

The grid style of valve has been revived by Mr. Strong, of Philadelphia, who proposes to work the same by a modification of Brown's gear; he accomplishes the quick and slow movements of his grid-valves by an ingenious combination of levers.

In these 20 different valve-gears brought before you, mixed and confusing as they appear, there are certain peculiarities in the method by which expansion and reversion are accomplished which enables them to be classified. We will include

1. The usual link motion, with its double eccentric, giving lap + lead + port opening, direct off-throw of eccentric, whose path is circular. Reversion and expansion are accomplished by moving link across valve-rod.

2. The single eccentric fixed on driven shaft, but free to revolve the angle necessary to reverse engine, which is accomplished by spiral sleeve. Expansion can only be accomplished by stopping engine and adding to driving stop; path circular. Travel of valve constant at all grades of cut-off.

3. Englemann's plan of doing same as No. 2, but with fixed eccentric opposite crank. Reversion and expansion accomplished on the principle of shifting eccentric strap 30° each side of neutral line. Travel of valve constant; path circular.

4. Hackworth's system, which accomplishes expansion and reversion by the varying angular motion of the fulcrum end of eccentric-rod. Path of valve-rod connection elliptical.

5. Waldegg's system, which accomplishes expansion and reversion by sliding valve-rod connection across vibrating or bell-crank link, whose neutral axis is fixed. Path of valve-rod connection circular.

6. Morton's system, which accomplishes expansion and reversion by sliding valve-rod connection across inverted quadrant. Path of valve-rod connection elliptical.

We thus see that most of the radial gears fall under the fourth, fifth and sixth class. Each of these different classes, whether considered as steam distributors or as mechanical arrangements, have their merits as steam distributors; as this has been handled in a thoroughly scientific manner in two papers published in *Engineering*, September 17 and October 8, 1886, also in the interesting and able paper read by Mr. Milton before the North-East Coast Institution of Engineers & Shipbuilders, in both of which, by the aid of Zeuner's diagrams, the movements of the principal gears are analyzed, I commend these papers to your careful study. In looking at these different classes as mechanical arrangements, the first thing a practical engineer considers is the number of moving wearing parts, with the relative strains on same. Looked at only in this light, our own opinion is that the usual link motion compares favorably with most of the gears, and notwithstanding the doom pronounced against it by Sir W. Siemens some nine years ago, we believe it will die hard. If there is anything that will hasten this more than another, it is the desire of the marine engineers to contract the fore-and-aft length of their engines due to tripling same, and the saving here will usually more than recoup the extra cost and royalties, which handicap most of the gears compared with the link motion.

Considered in relation to fore-and-aft room there is one serious thing against the link motion, and that is, it does not conveniently adapt itself to the altered position of the valve-chests unless we introduce vibrating levers, and when these are added to the cost, then most of the other gears will compare favorably as to price, and accommodate themselves to most of your requirements.

Having said this much for the link motion, we think it fair to state that there are some of the gears which have been brought before you which will compete with it as regards cost and results. Taking this into account as well as the fact that these same gears are better steam distributors, let us complete the comparison, and examine them as regards up-keep. Take the case of Hackworth's gear, having a large eccentric and sliding bars, and which has more sliding surface than other radial gears, the testimony of those who have recently adopted this style is that they have less repairs and adjustment than with the link motion; the same is the case to a greater extent in Marshall's gear. These gears have five working parts, when engines are working, as compared with the direct link-motion's ten, while the Joy, the Walschaert and the Morton styles, having about the same number as the link motion, yet wear better. A number of the other gears noticed in this paper have more working parts, and where this is necessary to the aim intended we think it is dearly bought.

Before closing, it may not be amiss to say a word about the patent rights of some of these gears, and as one scans the long array of patentees and reads their blue-books we cannot help thinking that there has been a good deal of appropriation going on. Hackworth truly has fallen among some who would strip him even of his honor. Waldegg has been ousted from his place of honor, and both Joy and Kirk have each had their essential parts appropriated. We would advocate giving the rightful patentee his due, but, as the hampered condition one finds himself in by the multiplicity of patents may frighten some from having anything to do with radial gears, let such remember that there are some first-class gears free to the public.

If, in the different branches of the profession we fill, this paper should help you to so grasp the merits and demerits of the different gears, so that whether in working, overhauling, repairing or designing any particular gear you will be able to understand its principle, know its good qualities, keep your eye on its faults, and do it justice, my object in bringing this subject before you will be attained.

THE CLYDE TUNNEL.

(From the London *Engineering*.)

In the last session of Parliament power was granted to a private company to construct a tunnel under the river Clyde, at Glasgow, to provide what has for many years been desired by the citizens—a means of taking vehicles across the river between the north and south divisions of the central part of industrial Glasgow. The contract for making the tunnel has now been let to Messrs. Hugh Kennedy & Sons, Partick, who have had considerable experience in such undertakings. They successfully completed a tunnel under the Forth & Clyde Canal several years ago in connection with a branch line of the North British Railway to Dumbartonshire, and they also constructed the greater part of the Greenock & Gourock Railway, in which there was a tunnel about 1½ miles long.

The river tunnel is to be situated at Finnieston, about the middle of the harbor, and a point most convenient for the traffic to the engineering works in the Anderston and Finnieston districts, and also in connection with the Queen's Dock and the New Cessnock docks now being constructed. Many proposals have been made for meeting the traffic, which at present has to go by the bridges, a mile further up the river, among the suggested schemes being high-level bridges, with roads on gradients, hydraulic hoists, and spiral railways; semi-high level bridges, with swinging girders; swing bridges, etc. The difficulty in the adoption of the swing bridge was, of course, the interruption of traffic either on the river or the bridge when open, while the high-level bridges were condemned because of the length of the approaches. The Clyde Trust is having built a ferry for passenger and vehicular traffic, with a deck which is raised or lowered to suit the rise and fall of tide.

The plan proposed by Messrs. Simpson & Wilson, C.E., Glasgow, and adopted by Parliament, has many points of advantage. Of the scheme we give on the present page several illustrations, which practically explain themselves.

With three tunnels the vehicular traffic going south will have a separate subterranean passage, and there will also be one for the traffic going north, while the central tunnel is for passengers only. There will be only 2 ft. between the tunnels. The diameter of the part of the tunnel under the river, built in cast-iron segments, will be 16 ft.; that under the quays, where there is boulder clay, will be built of brick arching, and be 18 ft. in diameter. At their high-

est points the tunnels are to be 15 ft. below the bed of the river, thus leaving ample room for future dredging operations, and 35 ft. and 46 ft. respectively below low and high-water-levels. The shaft on the north side will be about 400 ft. west of Finnieston Street and 180 ft. from the quay wall, while the shaft on the south side adjoins the Govan Road, and is about 125 ft. from the quay wall. As the river is 415 ft. wide, the length of tunnel from shaft to shaft is 720 ft.

Both shafts will be round and 80 ft. in diameter. The shaft on the north side of the river will be 72 ft. 6 in. deep, and that on the south side 75 ft. 6 in. deep.

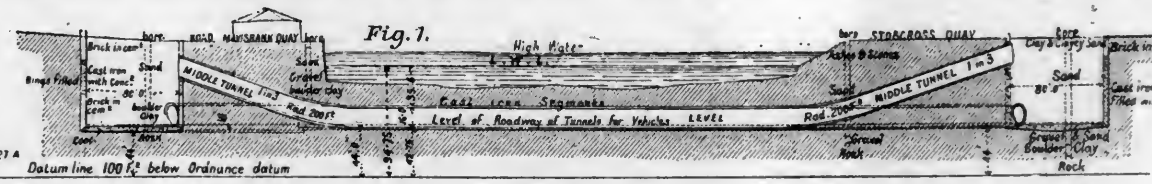
Operations are to be started at once on the south side of the river. Borings have proved that at a depth of 45 ft. boulder clay is met, which continues till the bottom of the shaft is reached, where again rock is found. The boulder clay will enable the contractor to start his tunneling northward with the surety that he will be free from water for a good distance. The shaft is to be formed of an outer and inner ring of cast-iron segments or plates measuring 4 ft. long by 2 ft., and of ½-in. metal with 3-in. flanges bolted together. The surface having been made perfectly level, the two rings forming the first segment will be placed in position, and the 4 ft. between the rings filled with concrete. To the bottom of the segment will be fitted a cutting edge of V section.

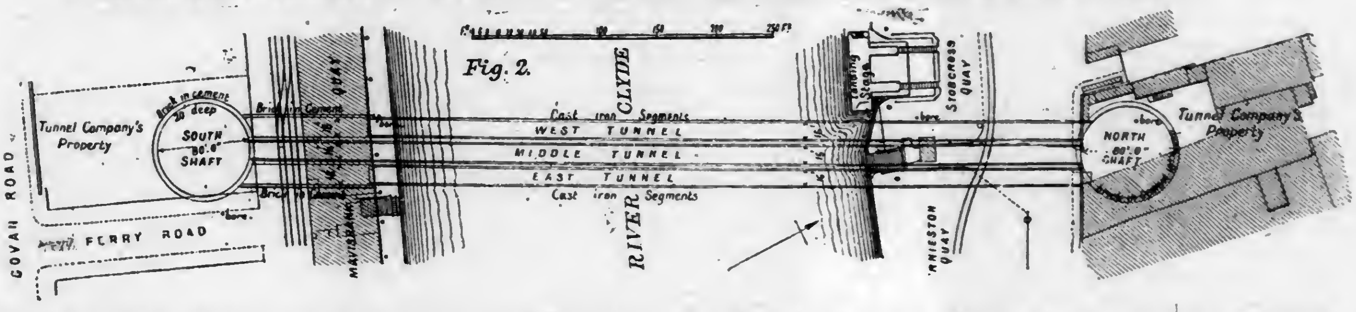
The excavation of the material occupying the space inside the segment will cause it, of its own weight, to sink, and segments will be added as the cylinder sinks down. When this cylinder reaches a depth of 27 ft., the bolting on of additional segments will be discontinued; but the cylinder will still be sunk until the boulder clay is reached—at a depth of 45 ft. From the top of the cylinder, when in its final position, to the surface level—18 ft.—the wall of the shaft is to be ordinary brickwork in cement, while the bottom part of the shaft is also to be walled with brick, as there the boulder clay does not require the cast-iron segments. At its final depth of 75 ft. the walls will have rock for their foundation, and the flooring will be of concrete.

The shaft on the south side having been completed in the manner described, the tunneling will be started in a northern direction. For a distance of at least 100 ft. the material is boulder clay, with the Mavisbank Quay on the surface. This part will be constructed on a concrete invert flooring, with circular brick lining 2 ft. thick (five rings), the diameter being 18 ft. The remaining part of the tunneling is of iron segments 1 in. thick, measuring 4 ft. long and 18 in. broad, with flanges 1½ in. by 6 in. deep, strengthened by stiffeners 12 in. apart. Between the segments there is a space, ⅜ in., for wedging up with soft wood, so as to make it water-tight. This system of wedging up iron segments has been largely adopted in the north of England, under great pressures, sometimes as much as 200 lbs. to the square inch. In the case of the Clyde Tunnel the pressure is not expected to be more than 25 lbs. to the square inch.

The method of procedure in constructing the tunnel under the river will be similar to that adopted by Mr. Greathead in connection with the Southwark Subway. In the case of the Clyde Tunnel a good start will be got from the 18-ft. brick tunnel already described. The boulder clay, it is thought, reaches to half-way across the River Clyde, and until the wet sand is met with no air pressure will be used. The work will proceed in 18-in. lengths. The contractor will probably manage to obviate the necessity of taking the material through an air-lock, a tedious process. For the first two or three lengths the material will be taken through the air-chamber; but after that the contractors will probably adopt the system of stowing the material along the insides of the tunnel, leaving only a center passage for working operations. The material can then be taken out after the tunnel is completed.

On the north side of the river the material is wholly wet

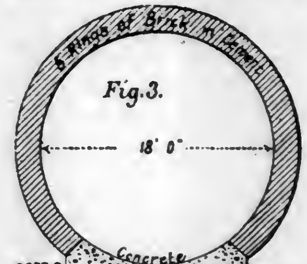




sand, and, of course, the cast-iron segments will form the tunnel to the shaft.

The shaft on the Finnieston (the north) side of the river will be carried 80 ft. below the surface level. The process to be adopted will be similar to that in the case of the south shaft; but heavy pumping will be required to keep the material clear of water while the excavations are being made. Cast-iron segments similar in construction will be sunk the whole depth, but for 18 ft. above the segments the wall of the shaft will be formed of brickwork. The foundation of the shaft will be composed of concrete 8 ft. thick in the center and thinning to 4 ft. at the sides.

The segments on the inside of each shaft will have their flanges turned inward, except where the tunnels are intended to enter the shaft. At these points the flanges are turned outward in the case of the inner ring of the seg-



ments, so that the bolts will be exposed and the segments easily removed for the bolting of the tunnel to the side of the shaft. When this is being done a cast-iron round air-tight cover will be bolted over the place where the junction is to be made. This will allow the connection to be made under air-pressure, which is necessary, as the material is wet sand. The round cover can only be removed when the connection is finished and bolted.

The center tunnel, which is for passenger traffic only, is to be formed of iron segments from shaft to shaft. The gradients of 1 in 3 at the ends will have flat stairs, and from the landing, which will take up the inner half of each shaft, there will be stairs to the street level, thus obviating the necessity for hoists, against which there seems to be a prejudice in the public mind.

The outer half of each shaft is to be fitted with six hydraulic hoists for vehicles. The two center hoists are to take 10 tons each, and will be worked on the balanced principle. Of the other four lifts two will be capable of raising 7 tons each and the other two 5 tons each. These will be worked independently of each other. The hoists on one side will be used in connection with the tunnel for traffic going northward, and the other two for the southward traffic. In this way the possibilities of the hoist not being in position for use when required are reduced to a minimum.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.
IV. LARD OIL. (*Continued.*)

By C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page 77.*)

THE specifications for *lard oil* on the Pennsylvania Railroad have been revised twice, each time an effort being made to so shape the specifications that they would give oils for use which would meet all the possible requirements of the service, and at the same time would check any disposition on the part of the manufacturers or dealers to sell an inferior article at the price of a good one. Following is a copy of the latest revision, which represents the specifications for lard oil now in use.

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Lard Oil.

Two grades of lard oil, known in market as "extra" and "extra No. 1," will be used, the former principally for burning and the latter as a lubricant.

The material desired under this specification is oil from the lard of corn-fed hogs, unmixed with other oils, and containing the least possible amount of free acid. Also from October 1 to May 1 it should show a cold test not higher than 40° Fahrenheit. Oil from lard of "mast," or distillery-fed hogs, does not give good results in service, and should never be sent. Also care should be taken to have the oil made from fresh lard. Old lard gives an oil that does not burn well, and also gums badly as a lubricant. The use of the so-called neat's-foot stock, either alone or as an admixture in making the "extra No. 1" grade, is not recommended. Neat's-foot oil is used by the Railroad Company when the price will admit, but it is preferred to have it unmixed.

Both grades of oil will be purchased on sample, and shipments must conform to sample. A four-ounce sample is sufficient, and should be sent as directed by the Purchasing Agent. The color of the sample has an influence in the placing of orders. Those lightest in color are regarded as best.

Shipments must be made as soon as possible after the order is placed. All shipments received at any shop after October 1 will be subjected to cold test and rejected if they fail, unless it can be shown that the shipment has been more than a week in transit.

Shipments of the "extra" grade will not be accepted, which

I. Contain admixtures of any other oils.

II. Contain more free acid than is neutralized by four cubic centimeters of alkali, as described below.

III. Show a cold test above 45° Fahrenheit from October 1 to May 1.

IV. Show coloration when tested with nitrate of silver, as described below.

Shipments of "extra No. 1" grade will not be accepted, which

I. Contain admixtures of any other oils.

II. Contain more free acid than is neutralized by 30 cubic centimeters of alkali, as described below.

III. Show a cold test above 45° Fahrenheit from October 1 to May 1.

The cold test of oils is determined as follows: A couple of ounces of oil is put in a four-ounce sample bottle, and a thermometer placed in it. The oil is then frozen, a freezing mixture of ice and salt being used if necessary. When the oil has become hard, the bottle is removed from the freezing mixture and the frozen oil allowed to soften, being stirred and thoroughly mixed at the same time by means of the thermometer, until the mass will run from one end of the bottle to the other. The reading of the thermometer, when this is the case, is regarded as the cold test of the oil.

The amount of free acid in oils is determined as follows: Have ready (1) a quantity of 95 per cent. alcohol, to which a few grains of carbonate of soda has been added, thoroughly shaken and allowed to settle; (2) a small amount of turmeric solution; (3) caustic potash solution of such strength that 31½ cubic centimeters exactly neutralizes five cubic centimeters of a solution of sulphuric acid and water, containing 49 milligrams H_2SO_4 per cubic centimeter. Now weigh or measure into any suitable closed vessel, a four-ounce sample bottle, for example, 8.9 grams of the oil to be tested. Add about two ounces of the alcohol, warm to about 150° Fahrenheit, add a few drops of the turmeric solution and shake thoroughly. The color becomes yellow. Then add from a burette graduated to cubic centimeters, the caustic potash solution, little at a time, with frequent shaking, until the color changes to red, which red color must remain permanent after the last vigorous shaking. The number of cubic centimeters used shows whether the oil stands test or not. In the case of the "extra" grade, if more than four are used, or in the "extra No. 1" grade more than thirty are used, the oil fails.

The nitrate of silver test is as follows: Have ready a solution of nitrate of silver in alcohol and ether, made on the following formula:

Nitrate of silver,	1 gram.
Alcohol,	200 grams.
Ether,	40 "

After the ingredients are mixed and dissolved, allow the solution to stand in the sun or in diffused light until it has become perfectly clear; it is then ready for use and should be kept in a dim place and tightly corked.

Into a 50-cubic centimeter test tube, put 10 cubic centimeters of the oil to be tested (which should have been previously filtered through washed filter paper) and five cubic centimeters of the above solution, shake thoroughly and heat in a vessel of boiling water 15 minutes with occasional shaking. Satisfactory oil shows no change of color under this test.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., March 19, 1889.

It will be observed that the specifications state, first, what kind of material is desired, and, second, what kind of material will be accepted. The material which will be accepted is not always the material that is desired, and this distinction is pervading all the more recent specifications issued by the railroad company. A want of care in reading the specifications by the manufacturers has frequently led them into serious difficulty. They have based their action on that part of the specifications which tells what is desired, not noticing, first, that the specifications always give certain limits either side of the material desired, and, second, forgetting that in commercial processes producing manufactured products usually the methods are not capable of giving results that are very close to what is aimed at. It is very much safer to take the limits

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* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I., in the JOURNAL for December, is on the Work of the Chemist on a Railroad; No. II., in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III., in the February number, is on Lard Oil. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION of special value in indicating the true character of the materials they must use and buy.

which will be accepted, and then allow margin enough so that the product will never come below or above those limits. That part of the specifications which describes what is desired is regarded as representing what material in our experience will give the very best results in service, and the nearer manufacturers can get to this the better.

The reason for desiring material from corn-fed hogs, and for avoiding that from mast-fed or distillery-fed hogs, has already been explained, as well as the effect of admixtures of cotton-seed oil with the lard oil. It goes without saying also that admixture of cheaper oils with higher-priced oils is a fraud, and therefore specifications must guard against it. The requirements against free acid have a twofold reason. First, the amount of free acid in an oil is in many cases evidence of the stock used in making it, and as has already been described, if the amount of free acid is high, it is evidence that a poor quality of lard has been used in making the oil. There is also another reason for avoiding large amounts of free acid in lard oils. Free oleic acid apparently oxidizes readily on exposure to the air, and the more free acid there is in an oil the less satisfactory results are obtained from it, both as a burning oil and as a lubricant. We have not demonstrated that this is due to the presence of the free acid itself, but our experiments show that the larger the amount of free acid the more difficulty is experienced in maintaining the light, when the oil is used for burning, and the more readily the oil gums when used as a lubricant. It may be that the cause for this is the presence in the oil of other substances, possibly decomposed tissues, which are an accompaniment of larger amounts of free acid. Whatever the cause, the fact remains that the prime grade, if high in free acid, does not give good results as a burning oil, and the extra No. 1 grade being high in free acid is not as good for lubricating purposes.

The freshness of the lard used in making the oil is also an important element. Positive experiments made with a signal oil which had been kept five or six months showed that its burning qualities had deteriorated very greatly. The detail of this experiment is interesting. A sample of signal oil was made up in the usual way, the constituents being *extra lard oil* of excellent purity and quality, and the usual amount of petroleum product. A burning test was made with an ordinary hand lantern and a new wick. This oil showed on test, several times repeated, that a good flame could be maintained without trimming the wick for from 30 to 35 hours' continuous burning, care being taken to keep the pot supplied with oil. Some of this same oil was then put in a bottle and kept, being protected from dirt, but access of air allowed through the neck of the bottle, with occasional agitation of the oil. At the end of six months this oil had lost its burning qualities almost entirely. In no case could a lamp with a new wick and fresh trimming be kept lighted over seven or eight hours without going out. This experiment was repeated times enough to eliminate chance variables, and all our experience on the road confirms this view—namely, old signal oil does not burn satisfactorily. After these experiments were made, instructions were issued to the men that they should not order signal oil enough at any local point to last them longer than two months.

The same difficulty is experienced in a modified degree with oil made from old lard, and every year, especially during the months of June, July and August, the signal oil is less reliable than three months later, after the new killing and freshly-made lard begins to appear.

The paragraph in the specifications in regard to neat's-foot oil or neat's-foot stock is perhaps worthy of a moment's notice. During the past 14 years we have found many shipments of oil which were not pure lard oils, but were apparently mixtures of lard oil with some product which came from beef. On tracing out the matter by inquiry among the manufacturers who made the oil, it was found in certain portions of the country, and especially during the months of May, June and July, quite large amounts of grease could be obtained which contained considerable percentages of material from beef. As will be explained further on, tallow oil is simply nothing but the soft, oily part of the tallow separated from the stearin, in the same manner that the lard is separated from the stearin of the lard, and in reality these oils were mixtures of lard oil with oily matter from beeves. It usually does not pay to attempt to make oil from the tallow of country-fed cattle, the amount of oil obtained being so small; but if the cattle have been fed on distillery slops the amount of oily material is apparently largely increased, and this objection no longer remains. In the case above cited, where the source of the stock making this mixed oil was known, the stock came from regions where there were large distilleries. This peculiarity in regard to mixed lard and neat's-foot or tallow oils applies only to the *extra No.* 1 grade, and no serious difficulties have ever been experienced with the mixed oil in service. The reason why for the restriction in the specifications is more to enable the railroad company to be sure that it is not buying mixtures of various oils under the name of a pure product, than because of inability to use the mixed product.

The explanation of the method of buying on sample, and of the color of the samples, have already been stated. The requirement that shipments should be made as soon as possible after the order is placed is for the sake of keeping the stock on hand as small as possible. Orders are placed for these grades of oil once a month, and if a delay of two or three weeks occurs in making the deliveries, the various shops get out of supplies.

There are some places in the country where summer and winter oils are still made, and in order to allow these to compete it has been found essential to use a cold test at certain seasons of the year. At present the limits are from October 1 to May 1. It is, of course, fair to say that if the autumn proves warm there is no real necessity for a cold test until cold weather begins; but as this cannot be foreseen, the time of the cold test has to be made purely arbitrary. Considerable difficulty, more especially with certain of the petroleum products used for lubrication, is experienced if any inspection point is caught by a cold snap with a heavy stock of summer oil.

The tests made use of are directed to obtaining three results: First, to prevent an inferior grade being sold under the name of a better grade; second, to prevent the admixture of other oils with the kind bought; third, to secure such a quality of each oil as will give the best results in service. For the first of these points—the prevention of the acceptance of an inferior under the name of a better grade of oil—we rely largely on the amount of free acid, color and odor also being used. The method of determining the amount of free acid and the reasons why for each of the steps has already been given in the article in this series on "Tallow." The method is repeated above as part of the specifications for lard oil. In the prime grade color is not taken into account. In the *extra No.* 1 grade color has its influence, as has already been described. It is quite possible that the free acid test to protect against receiving inferior materials of a low grade would break down under certain conditions. For example, it is possible to make an oil from some of the so-called "yellow greases" of the market, which would not exceed the limits of free acid above mentioned in the specifications for extra No. 1 lard oil, but in our own experience this is very rarely if ever done. If such material should be offered it would be very easy to reject it on color and odor, or to so modify the specifications as to exclude it. Our experience has not indicated the necessity for this, however, and if the limits of the specifications are maintained, oil unadapted to the work, so far as receiving inferior material under the name of a better is concerned, will probably rarely occur.

Under the head of the quality of the oil, the cold test, and the adaptability of the oil to the service required of it, is comprehended. The method of making cold test is described in the specifications. It consists in brief in freezing the oil and then allowing it to thaw while a thermometer is in it, calling that temperature the cold test when the material in the bottle has sufficiently softened so that the mass will run from one end of the bottle to the other. In actual practice we find that the oil does not look like oil, but rather like a soft grease, when this point is reached. We are well aware that this method of making cold test is not the one in customary use. The ordinary practice is to place the bottle containing the oil in a freezing mixture or surrounded by cold, a thermometer suspended from the

cork having been placed with its bulb just below the surface of the oil, in the center of the bottle. The thermometer is read when the oil surrounding the bulb is just on the point of congealing, and this reading is regarded as the cold test of the oil. We formerly used this method, but abandoned it after very careful experimentation, the reason being that we could not get uniform results—that is, different tests on the same oil did not give the same results. According to our experience the cold test in this method is affected by the rate at which the oil cools, and is also not the cold test of the mass, but the cold test of those constituents of the oil which congeal at the lowest temperature. Furthermore, the method requires constant watchfulness on the part of the operator in order to seize the right moment when the last of the oil congeals. In order to make some of these points clear, it will be necessary to state that most, if not all, the oils of which cold tests are made contain constituents of different solidifying points, and when oil is exposed in a bottle to a sufficiently low temperature, so that any or all of the constituents will solidify, those constituents which solidify at the highest temperature apparently solidify first around the sides of the bottle, leaving the more limpid constituents unsolidified and crowded toward the center of the bottle. This process goes on gradually, effecting a separation of those constituents which have the lowest solidifying point, so that in reality by the common method, as above described, the cold test is simply the cold test of those constituents of the oil which have the lowest solidifying point. The separation of the constituents by cooling is affected by the rate of cooling. If the cooling is very rapid, the separation is much less ; if it is slower, separation is much greater, and this often leads to variations in results in the same sample, as above described. In our method, however, it is believed these results do not follow. One of the principal reasons for taking cold test is to secure an oil which will run from the can, and consequently we have chosen that point at which the oil will run from one end of the bottle to the other as representing the cold test. Furthermore, it will be noticed that we mix the oil thoroughly with the thermometer while it is melting, and so we get the cold test of the whole oil and not a fraction of it. It is fair to state that with careful manipulation duplicate results can be obtained within one degree, although we do not usually enforce the results of this test as closely as this. It is also fair to state that the whole criticism above of the method of making cold test is much more applicable to petroleum products than lard oils, and some further statements in regard to cold test and methods of making will be made in a subsequent article on Petroleum Products.

It will doubtless be a surprise to many who are acquainted with the literature of the case to know that we regard the nitrate of silver test more as a test of quality than of purity, since that test, not exactly as described in the specifications, but with certain modifications, is generally supposed to be a test for the presence of cotton-seed oil. The complete test, we believe, is known in the literature of the case as Bechi's test. Our experience with the test, however, indicates that it is not reliable as a test for the presence of cotton-seed oil. It is not applicable to *extra No.* 1 lard oil, in the condition in which it is received from the manufacturer, under any circumstances, either pure or adulterated. The brownish color which is characteristic when cotton-seed oil is present is also produced by certain substances in the *extra No.* 1 lard oil, so that lard oil of that grade, containing no cotton-seed oil whatever, might test as though it had a large percentage of cotton-seed oil. This difficulty has been overcome, it is claimed, by the modification proposed by Millian, which consists in saponifying the oil, separating the soap, and then decomposing the soap. This, it is claimed, gives the free fat acids unmixed with any other substances, and which can be tested with nitrate of silver. If they show the brownish coloration it is evidence of the presence of cotton-seed oil.

It will be observed that we use the nitrate of silver test only on the best grade of lard oil. The necessity for some test of this kind arises in our experience from finding that much of the extra lard oil which was obtainable in the market did not give satisfactory results on burning test, although it would pass all the tests of our previous specifications. The characteristics of these extra lard oils during burning were serious coating of the wick and shorter length of time that the flame would maintain itself without retrimming. It has already been stated that when a lard oil contains large amounts of free acid, or when it has become somewhat old, it does not give satisfactory results as a burning oil. To such an extent is this true that, although we have tried many times to make a signal oil, using the cheaper or *extra No.* 1 grade in the market, we have never succeeded in getting an oil which would give a satisfactory light for more than 10 or 12 hours, and have never felt willing to trust such an oil. So far as we can decide, the reason why *extra No.* 1 lard oil does not give good results in burning is apparently a question in part of the amount of free acid, since, as previously stated, free oleic acid seems to have more of a tendency to oxidize and become resinous than olein alone. The presence of free acid, however, does not account wholly for the difficulty, since an oil containing almost no free acid will in time lose its burning qualities, as has already been explained. Also, it is possible to obtain in the market oils containing not more free acid than our specifications allow, which have been produced from extra No. 1 or lower grades of oil, by removing the free acid. These oils pass the ordinary tests, and in appearance are satisfactory as prime or extra lard oil, but when made into signal oil they do not give satisfactory results. Both these effects—namely, the deterioration of the best grade of oil by time, and also the behavior of oil from which the free acid has been removed, lead us to the idea that there is, or is developed by time, in lard oil of both grades, something which is detrimental to its burning qualities. Just exactly what this is we are unable to say. Our suspicion is that it is nitrogenous matter, coming originally from the tissues, and which is more or less gluey in its nature. It is also possible resinous matter may be developed by slow oxidation. Whatever the material is, we found a necessity for some test that would enable us to reject oil which will not give good results after it is made into signal oil. The most obvious test would be simply to make up a small batch of signal oil and make burning test, but this test is too slow. We are frequently called upon to give a decision in regard to 10 or 15 shipments in a day, and a burning test requires anywhere from 20 to 30 hours of continuous burning. In our experience the nitrate of silver test accomplishes this very purpose—namely, an extra or prime oil which becomes brownish when treated as described in the specifications, with the nitrate of silver test gives poor results in burning. We do not attempt to say whether these poor results are due to an admixture of cotton-seed oil or to an oil made from old lard or from a purified extra No. 1. Whatever the cause, the nitrate of silver test gives us a means of excluding oils which our experience indicates are not such oils as we want.

Two points in the method of testing as described are worthy of note. It will be observed that it is suggested to filter the oil through washed filter paper before making the test. The reason for this is that it has been found that many oils contain suspended matter, apparently bits of tissue which affect the test. These bits of tissue or other suspended matter settle out after the oil is made into signal oil, and do not cause any difficulty in service, and we therefore recommend to remove them by filtering before testing with nitrate of silver. It will also be observed that a statement is made in the specifications that satisfactory oil shows no change of color under this test. It is fair to say that we find few samples of extra or prime lard oil which show no change of color whatever, and that therefore if the strict wording of the specifications was followed it would probably be difficult to obtain in the market sufficient oil to supply the road. We spent considerable time in trying to define a limit of change of color. As stated above, the change produced by the treatment with nitrate of silver is a more or less brownish coloration, and we tried to give a limit of change of color beyond which we would not go. Any one who has attempted to define shades will appreciate the difficulty. We meet this difficulty in this case, as in all cases in our specifications where a little ambiguity seems to be unavoidable, by the

use of a little good common sense. We do not reject shipments of oil which show very slight changes of color on test. More marked changes are ground for rejection, the rule being that the change should be so marked that the manufacturers or dealers would, if they are fair, say that the oil did not pass test. The Pennsylvania Railroad specifications are not intended as devices to snap people up on technicalities, but to secure in the market such materials as will be an honest equivalent for the money paid for them, and will give the service that is required. Some manufacturers regard the nitrate of silver test as too sensitive and delicate for practical use, and are inclined to complain a little at the decisions reached by it. Our experience now for a number of months with this test, using, as said above, good ordinary common sense along with it, has convinced us that it is a very valuable one, and we should be very much disinclined to accept shipments of extra lard oil without testing them in this way. It should be remembered that the amount of this grade of oil that railroad companies use is not very large at the most, and that the results depending on this oil are very important, and we cannot help feeling therefore that railroad companies are entitled to the best oil of this grade that the market affords.

It is at present possible to mix with lard oil of either grade two kinds of cheaper oils as adulterants. These oils may be classed as non-saponifiable and saponifiable adulterants. The petroleum products and rosin oil are examples of non-saponifiable adulterants, and cotton-seed oil the best example at present prices of saponifiable adulterants. In trying to exclude these adulterants we rely partly on what is known as Maumene's test, or Hubl's iodine test, or possibly Millian's modification of Bechi's test with others, and also partly on quantitative saponification. Maumene's test, as is well known, is simply a measurement of the rise in temperature produced when certain amounts of the sample to be tested are mixed with strong oil of vitriol. We usually use 20 cubic centimeters of the oil sample and 10 cubic centimeters of the oil of vitriol. The oil sample having been placed in a small beaker, the oil of vitriol is added and the two are mixed by stirring with a thermometer, care being taken to have both the ingredients, the thermometer, and the dish at the same temperature, usually 80° Fahrenheit, when the mixing begins. Under these conditions a rise of temperature of about 80° is obtained when the lard oil is pure. Samples of pure lard oil vary a little in our experience, but usually not more than three or four degrees. We think these variations in pure oils are due probably to variations in the proportions of the stearin and olein in the sample, since our experience shows that stearin gives a lower rise in temperature than olein. We also find that the strength of the oil of vitriol and the beaker and thermometer used affect the test somewhat. Our usual method is to take a carboy of oil of vitriol from the market and make a test with a sample of the oil which we know to be pure. This test, repeated several times, gives us what that oil of vitriol will do with pure oil, and as long as that carboy holds out, care being taken to exclude moisture, that figure can be taken as the rise in temperature for pure oil. The peculiarity in regard to the beaker and thermometer is a little singular. Two beakers of apparently the same size, and two thermometers tested in exactly the same way with the same oil and same oil of vitriol, will not give the same rise in temperature. There seems to be a characteristic of each beaker and each thermometer. It is, of course, understood that in making this statement we do not rely on a single figure for the different beakers. Enough tests in the same beaker are always made to eliminate accidental differences, and so convinced are we of this peculiarity of beakers and thermometers, that whenever a new lot of beakers are obtained we always make a number of tests with each beaker with its thermometer to get the characteristic of the beaker, and then scratch it on the glass with a diamond point. We are unable to account for this peculiarity. It seems probable, however, that the rate of transmission of heat through the sides of the beaker will do something toward explaining it. Usually the test is made without any non-conducting cover to the beaker, and if one beaker loses heat more rapidly than another, obviously not the same rise in temperature would be obtained in the two. This same peculiarity of loss of heat during the time of making the test, approximately from half a minute to a minute, introduces another source of error—namely, the atmosphere at certain times apparently cools the beaker more rapidly than at others, thus occasioning a slightly different rise in temperature at different times, even with the same beaker. The error due to these variables may be sufficient to cause a wrong judgment to be passed in regard to an oil which is being tested, and accordingly we take great pains in all our tests to have all the conditions made as constant as possible. Maumene's test, being so simple and so easily applied, must be regarded as a very valuable one. Each kind of oil which we have run across in our experience has its own characteristic rise in temperature. As will be observed in the way in which we perform the test, pure lard oil gives a rise in temperature of about 80°. Tallow oil and neat's-foot oil give a rise in temperature some 12° lower; olive oil not far different from lard oil. Petroleum products give a very slight rise in temperature, sometimes not over 5° or 10°. Cotton-seed oil, on the other hand, gives a rise in temperature of 137°. Most of the other animal and vegetable oils give considerably higher rise in temperature than lard oil. Mixtures of oils give a rise in temperature somewhere between the limits of the two when tested alone. For example, a mixture of half tallow oil and half lard oil will give a rise in temperature of 74°, on the supposition that tallow oil gives a rise in temperature of 68° and lard oil 80°. Also a mixture of half lard oil and half cotton-seed oil would give a rise in temperature of 109°—that is, half way between 80° and 137°. It will thus be observed that if the sample of oil which is being tested does not give the characteristic rise in temperature corresponding to the oil which is supposed to be present, suspicion at once arises that some other oils are mixed with it. If the rise is above that of lard oil, some of the animal or vegetable oils giving a higher rise in temperature are suspected. If it is below, either petroleum product or some of the animal or vegetable oils giving a lower rise in temperature are suspected. In our experience, embracing now some eight or nine years, we have found in the market only olive oil, tallow oil, the petroleum products, and rosin oil which give a lower rise in temperature than lard oil. All of the other oils which we have tested, embracing the fish oils, and most of the animal and vegetable oils, give a higher rise in temperature.

The value of the Maumene test is very great, but it does not tell all that is required to be known; three cases might arise, as follows:

First, if the sample being tested gives a higher rise in temperature than is characteristic of lard oil, sufficient allowance being made for accidental rise, as above stated, we feel satisfied in saying that the oil is not pure lard oil from corn-fed hogs. The effect of the food on the oil has already been discussed.

Second, if the rise in temperature is that which is characteristic of lard oil, it is very strong evidence that the oil is pure, but not positive proof. The reason for this is that a mixture, for example, of tallow oil, neat's-foot oil, or rosin oil with cotton-seed oil may be made in such proportions as to give the rise in temperature which is characteristic of lard oil, so that actually a sample which contains no lard oil whatever, if tested by Maumene's test alone, might be pronounced pure lard oil. The proportion of cotton-seed oil, however, to produce this result would be at least 25 per cent., and so large a percentage of cotton-seed oil could easily be detected by Millian's modification of Bechi's test, unless perchance the cotton-seed oil was treated in such a way as to cause it to fail to give reaction with Bechi's test. This, of course, is possible, and in this case further study would have to be put upon the sample and tests made, which it is hardly within our present purpose to describe. Our object now is to give the methods in common use in well-known laboratories for testing.

Third, if a sample in question causes a rise in temperature with Maumene's test, lower than corresponds to pure lard oil, the presence of tallow oil, neat's-foot oil, or of some of the petroleum products or rosin oil would be suspected. If tallow oil, neat's-foot oil, or olive oil is

present, there would very little difficulty arise in the service, as all of these oils are about as good for all purposes as lard oil, and at present their prices are such that there would be very little tendency to use them as adulterants. If petroleum products or rosin oil were present, however, the results in service would be not so good, and also there would be quite a wide margin for fraud. To check up this test a saponification test is made. Pure lard oil requires a certain amount of caustic soda or potash to completely saponify any given amount. If now any given sample is treated with an amount of soda or potash sufficient to saponify it, and it is found by the subsequent operation that all the potash or soda is not used up, it is proof positive either that the saponification is not complete or that the oil contains some constituents which do not saponify. The process is so simple and so well understood by those making oil tests that it is probably unnecessary to describe it. We use an alcoholic solution of potash, and determine the amount of potash not used up by titration with standard acid, using phenolphthalein as indicator.

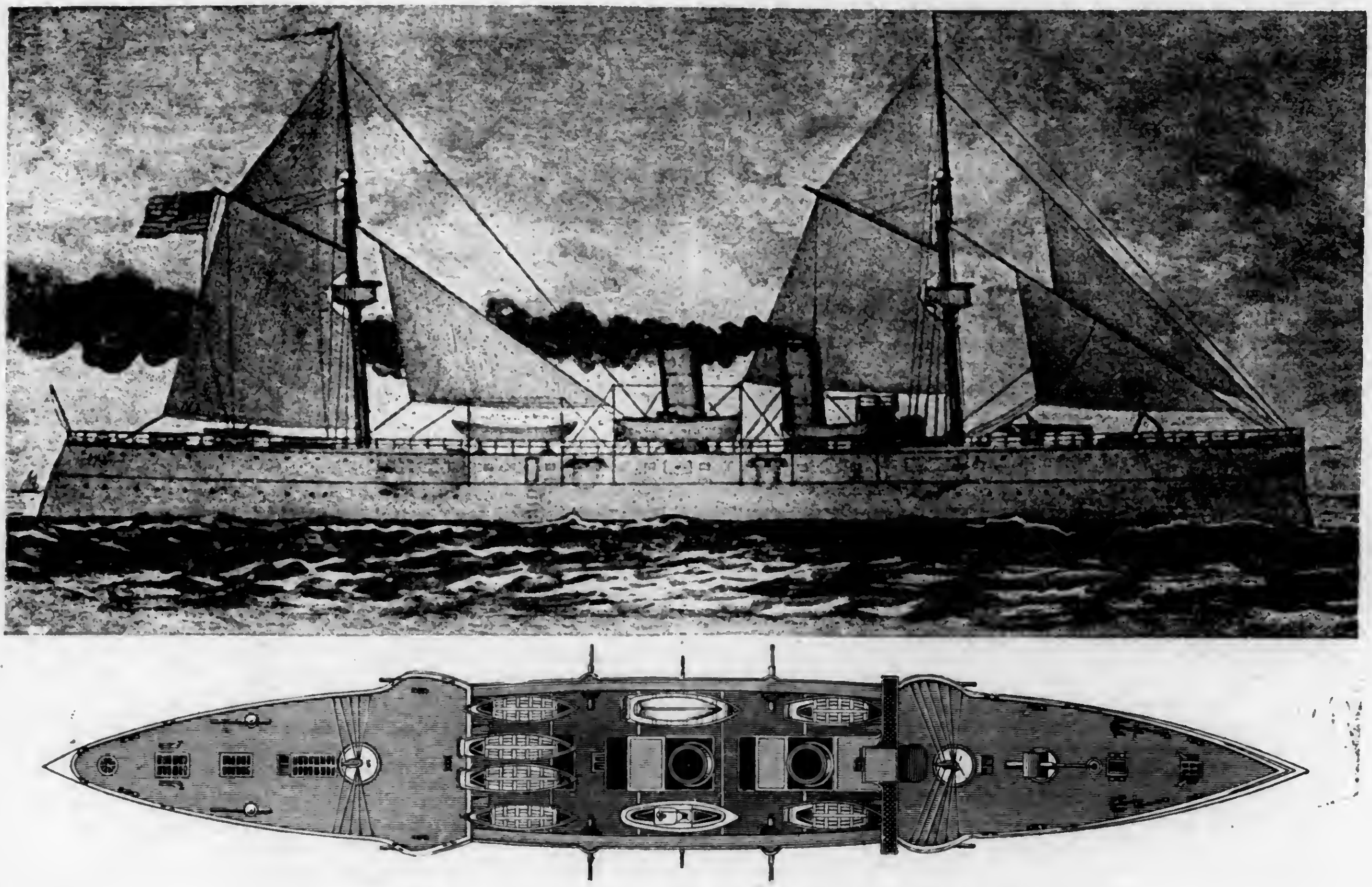
Hubl's test, which is based on the amount of iodine absorbed by certain fatty bodies when treated in the proper way, is similar in the results which it gives to Maumene's test—that is to say, if an oil gives a high rise in temperature with Maumene's test, it will usually but not always give a high absorption with Hubl's test. We think Hubl's test is valuable as a means of confirmation, or for investigation, or to help us decide a point, but in general its indications being so similar, and Maumene's test being so much simpler, we usually use Maumene's test.

It will thus be seen that we have two very simple tests—namely, Maumene's test and saponification, and that by means of these it is possible to pronounce quite positively whether a certain sample of oil is pure lard oil or not, the only exception being with all such mixtures as would give the same rise in temperature with Maumene's test as pure lard oil does, and the same saponification equivalent. As stated above, such cases in our experience are rather rare, and are met in our Laboratory by other tests which we do not deem it essential to describe here.

In concluding this perhaps too long article, it would probably be well to say that the freedom of the sample sent for test from admixtures of other oils is a point which needs to be looked after pretty carefully. In the system in use on the Pennsylvania Railroad the sampling of the shipments is done at the various shops where the shipments are received by an employé of the Company, and it has required considerable discipline to have the sample sent always in either a clean can or in a can which has been used for no other kind of oil except the kind of oil sent. All who have had any experience in this line will recognize at once what disastrous results would follow the sending of a sample of water white petroleum in a can which had been used for well oil, and not cleaned, and also sending a sample of extra lard oil in a can which had previously been used for extra No. 1 lard oil.

The next article of this series will be on the Petroleum Products used by railroads.

(TO BE CONTINUED.)



CRUISERS NOS. 7 AND 8 FOR THE UNITED STATES NAVY.

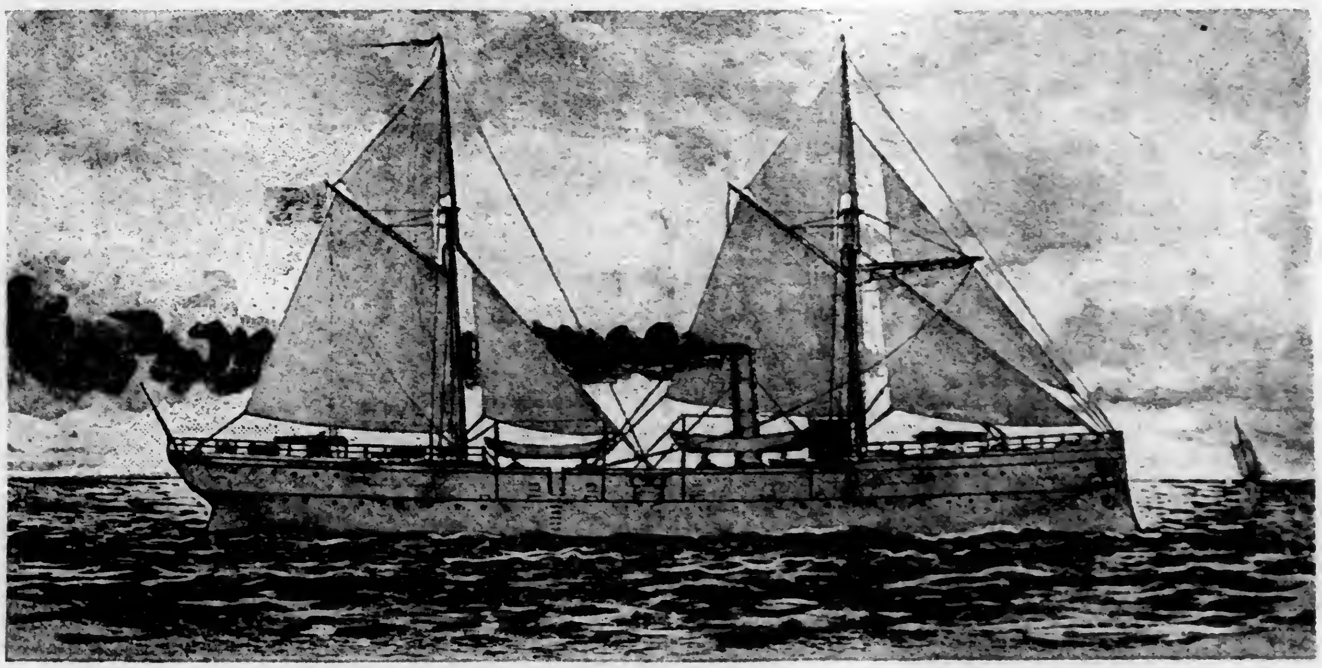
UNITED STATES NAVAL PROGRESS.

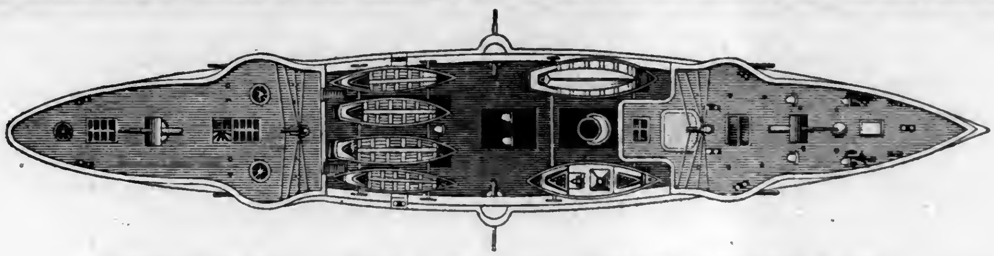
BIDS for the two 1,000-ton gun-boats—officially known as gun-boats Nos. 5 and 6—and for the practice ship for the Naval Academy, have been received. The Bath Iron Works, Bath, Me., bid $327,000 for one gun-boat, or $637,000 for the two. The Samuel L. Moore & Sons Company, Elizabeth, N. J., bid $285,000 for one gun-boat, $562,875 for two gun-boats, and $245,325 for the practice vessel. The Atlantic Iron Works, of Boston, bid $344,000 for one gun-boat. It is not yet decided to whom the contracts for these vessels will be awarded. Neither of these establishments has built any vessels for the Navy before.

The practice ship is to be 180 ft. in length, 32 ft. breadth, 11 ft. 6 in. mean draft, and 835 tons displacement. She will

have a battery of four 4-in. rapid-fire guns, with a secondary battery of machine and Gatling guns. The engines will be of the triple-expansion type and of some 1,300 H.P. The vessel will have all the appliances of the modern cruiser, including electric lights, torpedo-tubes, etc.

The gun-boats Nos. 5 and 6 are to be small, fast twin-screw, steel cruisers, carrying on a small displacement a battery of rapid-fire guns and a large supply of coal. The main dimensions will be: Length on load-line, 190 ft.; breadth, 32 ft.; mean draft, 12 ft.; displacement, 1,000 tons; indicated power of engine, 1,600 H.P. They will have double bottoms, and the machinery will be protected by the coal bunkers and by bulkheads filled with woodite.





GUNBOATS NOS. 5 AND 6 FOR THE UNITED STATES NAVY.

The main battery will consist of eight 4-in. rapid-fire guns, one on the poop, one on the forecastle, two under the forecastle mounted in sponsons, two under the poop in sponsons, and two amidships, also in sponsons. The secondary battery will consist of two 47-mm. and two 37-mm. revolving cannons, one one-pounder and one Gatling gun.

The engines will be of the vertical, inverted-cylinder, direct-acting, triple-expansion type, each with cylinders 15 in., 25 in. and 34 in. in diameter and 24 in. stroke. Steam will be supplied by four boilers 10 ft. in diameter and 17 ft. 6 in. long. The coal bunkers will hold 250 tons, and the cruising range on this supply will be 2,452 knots at 14 knots an hour, or 4,668 knots at 10 knots. There will be a steam steerer and steam windlass.

The rig, as shown in the accompanying illustrations—which are taken from the Report of the Bureau of Construction, and show a general view and deck plan—will be that of a schooner with a fore-yard and square foresail.

THE 3,000-TON CRUISERS.

Contracts have been let for most of the material for the new cruisers Nos. 7 and 8—the 3,000-ton cruisers—and the keel of No. 7 has been laid at the Brooklyn Navy-yard. This ship and the engines of both vessels will be built in that yard, while No. 8 will be built at the Norfolk Navy-yard. The general design of these ships is shown in the illustrations on page 126—taken from the annual report of the Bureau of Construction and Repair—which show an elevation and deck plan.

They will be twin-screw steel cruisers, with heavy protective deck. The latter slopes at the sides in two slopes of 22° and 39°; it will be 2½ in. thick on slopes amidships, 2 in. on slopes at ends and 1 in. on the flat. A coffer-dam is worked along in wake of the water-line next the outside plating in the coal bunker on the slope of the protective deck. This will be filled with woodite. They will have double bottoms throughout. The rudder will be of the balanced type.

The ships will be provided with electric lights throughout. The ventilation will be on the exhaust system.

The capacity of the coal bunkers will be 556 tons; with this supply the radius of action at various speeds will be: 20 knots per hour, 1,243 knots; 18 knots, 2,213; 16 knots, 2,964; 14 knots, 4,190; 12 knots, 5,925; 10 knots, 8,652; 8 knots, 9,982. Thus at an average speed of 10 knots an hour they can keep at sea 36 days without coaling.

The general dimensions of these ships are: Length on load-line, 300 ft.; extreme breadth, 42 ft.; mean draft, 18 ft.; displacement, 3,183 tons; indicated H.P. of engines, 10,000.

The armament will consist of one 6-in. breech-loading rifle, mounted on the topgallant forecastle as a forecastle pivot, and one 4-in. rapid-fire gun mounted on each side of the poop. In broadside on the spar deck there will be eight 4-in. rapid-fire guns, four on a side, the forward and after guns of each broadside being sponsoned for bow and for stern fire. The secondary battery will consist of two six-pounder and two three-pounder rapid-fire guns, two 37-mm. revolving cannon, and two Gatlings. In addition, they will be fitted with six torpedo tubes, disposed one in the bow, one in the stern, and two on each broadside.

The engines are triple-expansion, vertical, inverted and direct-acting, with a high-pressure cylinder 36 in., intermediate 53 in. and two low-pressure, each 57 in. in diameter, the stroke being 33 in. The condensers have each 7,000

ft. of cooling surface. There is a double, vertical, single-acting air-pump worked by a vertical compound engine for each engine. The circulating pumps are centrifugal, one for each condenser worked independently. The engines will be supplied by steam from four main boilers, two of them being 13 ft. 4 in. and the other two 14 ft. 6½ in. in diameter, and all of them 20 ft. 3½ in. long. These main boilers are double-ended. There are two auxiliary boilers, single-ended, 11 ft. 2 in. in diameter by 9 ft. 0½ in. long. The working pressure will be 160 lbs. The total heating surface is 19,382 sq. ft. and the grate surface 597 sq. ft. The forced draft system consists of a blower discharging into a main duct under the fire-room floor; from it a branch duct is led to the ash-pit of each furnace, means being taken for closing the ash-pits and preventing the leakage of gas from the furnace doors when under forced draft.

THE NAVAL POLICY BOARD.

The report of the Naval Policy Board has been transmitted to the Senate by the Secretary of the Navy. It begins by considering at length the work which may be required of the Navy in case of war, and also the conditions existing with respect to the construction of the new ships needed.

The Board is of opinion that the following vessels should be added to the United States Navy: Ten battleships of great coal endurance; 25 battleships of limited coal endurance; 24 cruisers of 4,000 tons and over; 15 torpedo cruisers of about 900 tons; 5 special cruisers for China service of about 1,200 tons; 10 rams for coast and harbor defense; 3 torpedo-depot and artificers' ships; 100 first-class torpedo boats and numerous second-class torpedo boats, carried by the battleships of great endurance and the larger cruisers and torpedo-depot ships.

In general terms the battleships of great coal endurance would constitute the basis of a fleet which might be detached in whole or in part for distant service and for the purpose of cruising against the enemy, having the power to remain at sea during a long period and to attack points on the other side of the Atlantic. It is absolutely essential to possess this number of battleships of such endurance, the Board thinks, because a policy of protection without the power to act offensively would at the present time double the force with which the United States would have to contend. An enemy, knowing it would be possible for such a fleet to appear upon its own coast, would be obliged to assign a superior force for its protection, thus greatly diminishing that to be sent against us.

The Board has considered the question of protection for guns and crews of cruisers, and believes that, within certain limits, the weight assigned to such protection is far more useful than the same weight in additional guns.

The following summary gives the distribution of the elements of the fleet, including all vessels built, building, appropriated for and recommended by the Board:

Battleships of Great Endurance.—Thirteen vessels, of an aggregate tonnage of 120,450 and total cost of $67,400,000.

Battleships of Limited Endurance.—Twenty-five vessels, of an aggregate tonnage of 179,200 and total cost of $110,000,000.

Harbor Defense and Rams.—Seventeen vessels, of an aggregate tonnage of 62,320 and total cost of $44,500,000.

Cruisers of All Classes (including gun vessels and dispatch boats).—Sixty-eight vessels, of an aggregate tonnage of 225,500 and total cost of $114,460,000.

Torpedo Depot Boats and Artificer Ships.—Three vessels, of an aggregate tonnage of 15,000 and cost of $6,500,000.

Sea-going Torpedo Boats.—One hundred and one, of an aggregate tonnage of 6,565 and cost of $6,565,000.

Total cost, $349,515,000, of which $67,965,000 is already expended or appropriated.

Reliance is placed on the development of an auxiliary navy of fast, well-built merchant steamers, to supplement the rather small proportion of cruisers contemplated in the programme.

One of the chief obstacles to carrying out this naval programme is the absence of a source of armor supply. There is only one establishment able to furnish the required armor, and unless others are prepared no large quantity of armor can be delivered before 1895. But the Board believes that if Congress will make appropriations immediately for a considerable number of heavily armored ships the demand for armor will induce the development of other large plants.

The best policy lies in concentrating available energy upon such a number of ships as can be completed in a reasonable time, and the efficiency of their type made available as soon as possible. The Board, therefore, believes that about 70,000 tons may profitably be laid down in the next two years, the distribution among the different types depending upon the capacity of the different shipbuilding establishments of the country. As much as possible of this aggregate tonnage, however, should be in battleships. It is believed that the work can be carried on at the following rate: 14 per cent. to be laid down in the first and second years, 10 per cent. in the third and fourth and 12 per cent. in each succeeding year, the programme to be completed in 14 years.

It is contemplated and urged that the four principal Navy-yards—viz., New York, Boston, Norfolk, and Mare Island, will be in the least practicable time completely equipped for constructing the hulls and machinery of all classes of vessels and their equipment, and with largely increased facilities for docking. The Board also recommends that the League Island Navy-yard be equipped as soon as possible for the construction of hulls of vessels.

The Board recommends that a wide series of artillery and torpedo experiments be made, and that to begin these experiments $100,000 be appropriated for immediate use. The Board also calls attention to the necessity of increasing coaling facilities at navy-yards and coaling stations and for coaling ships at sea. It is believed that suitable appliances can be determined upon and readily applied to ordinary colliers.

In his letter of transmittal the Secretary of the Navy says he does not coincide with the Board entirely. He is satisfied of the capacity of this country to complete the eight battleships recommended by the Department. As to what is considered an effective navy the Secretary repeats what he said on the subject in his annual report.

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C.E.

(*Continued from page* 80.)

CHAPTER XXII.

HOWE TRUSS BRIDGES.

The following plans of Howe Truss Bridges are not in strict conformity with the standard designs of any one railroad company. The Author has departed from these standard designs for the following reasons:

1. Comparing the designs in use upon the various roads in this country, much discrepancy was found to exist, not only in the details of construction, which might be expected, but in the actual size of the timbers used in the trusses. On different roads using the same type of locomotives and rolling stock, differences of such an amount exist as to make a divergence of not less than 50 per cent. in the actual strength of the trusses. One reason of this great difference is due undoubtedly to the fact that some of the designs were made some 10 years ago, and although they were forwarded to the Author during the last two years, it is to be hoped and is probably the case that the roads which furnished these plans are not now using them as standards.

2. There were no standard plans available that presented in consecutive order the lengths of spans desired, although we have a collection comprising spans of different lengths from the majority of railroads using Howe truss bridges in the country. Many of these bridges in use are badly de-

signed, and with very few exceptions none of them were intended to withstand the strain brought upon them by the present excessive locomotive and train loads.*

By the engineer or student of engineering in the East, the important part that wooden bridges not only form at present but will form for many years to come in our railroad systems, is not realized. On the older roads and on all roads running through the most thickly settled portions of the country, iron or steel bridges are either in actual use at present or any wooden bridges that do still exist will soon be replaced by metal. But on our Western roads and on all new roads in sparsely settled countries this is not the case, and for bridges not exceeding 150 ft. in span the Howe truss bridge, with compression members and bottom chord of wood still is and will continue to be the typical bridge. As to the actual amount of wooden bridging and trestling now in use upon our railroads, the following figures are taken from "Cooper on American Railroad Bridges" (*Proceedings American Society of Civil Engineers*, Vol. XXI., page 46).

From the previous figures, it would appear that there are now in existence on our railroads the following wooden and combination trestles and bridges :

Trestles and Spans under		20 ft	2,407 miles.
Spans wooden truss		20– 50 ft	35 "
"	"	50–100 ft	64 "
"	"	100–150 ft	97 "
"	"	150–200 ft	40 "
"	"	over 200 ft	7 "
Total			2,650 "

Of the 2,400 miles of trestle we can consider one-quarter as only temporary to be filled in as embankment. Of the remaining 1,800 miles 800 at least will be maintained in wood. This would give us ultimately 1,000 miles of wooden trestles and bridges and 1,600 miles of iron bridges on our 160,000 miles of railroad, of which only 380 miles are of iron up to the present time.

This free quotation will give some idea of the relative importance of wood and iron bridges.

During the years 1887 and 1888, of all the railroad bridges and trestles built in this country, over 75 per cent. of the number of structures were of wood, and this ratio will probably hold good for the next 20 years at least.

There is another point in regard to wooden bridges that renders them of much more importance to the railroad engineer than those of iron. In the majority of cases iron bridges are designed and erected by engineers who have made a specialty of them, and the railroad engineer usually does no more than check the strain-sheets furnished by some bridge company and examine and criticise the details of the designs furnished by them. This, of course, reduces much the work of the railroad engineer, and as the designs are made by experts, improves the character of the iron bridges erected and materially reduces their cost. In the case of wooden bridges, however, this is not the case. The railroad engineer must design, proportion, and erect these bridges. This work being added to the already multitudinous duties of the engineer, does not always receive the amount of attention necessary, and the result is that in a number of instances the engineers have taken the plans of some bridge already erected, changing some of its details to suit the new circumstances as far as length of span is concerned, etc. The result has been that some bridges have double the necessary amount of material, others have too little, while others are so badly proportioned that an excess of material is used on some members, while others only manage to withstand the strain brought upon them by the exceptional character of the material accidentally used.

In calculating the strains upon the following bridges, the locomotive diagram shown in Plate 100 has been used, and as the maximum span will be only 150 ft., the moving load has been considered as consisting entirely of 101-ton consolidation locomotives, as shown in the diagram. This load is much in excess of any that has been used in the

* The Author wishes to acknowledge his indebtedness to Mr. A. A. Robinson of the Atchison, Topeka & Santa Fé Railroad, and Mr. George C. Smith of the Chicago, Burlington & Quincy Railroad, for their kindness in furnishing him with very complete and satisfactory drawings of their Standard Designs.

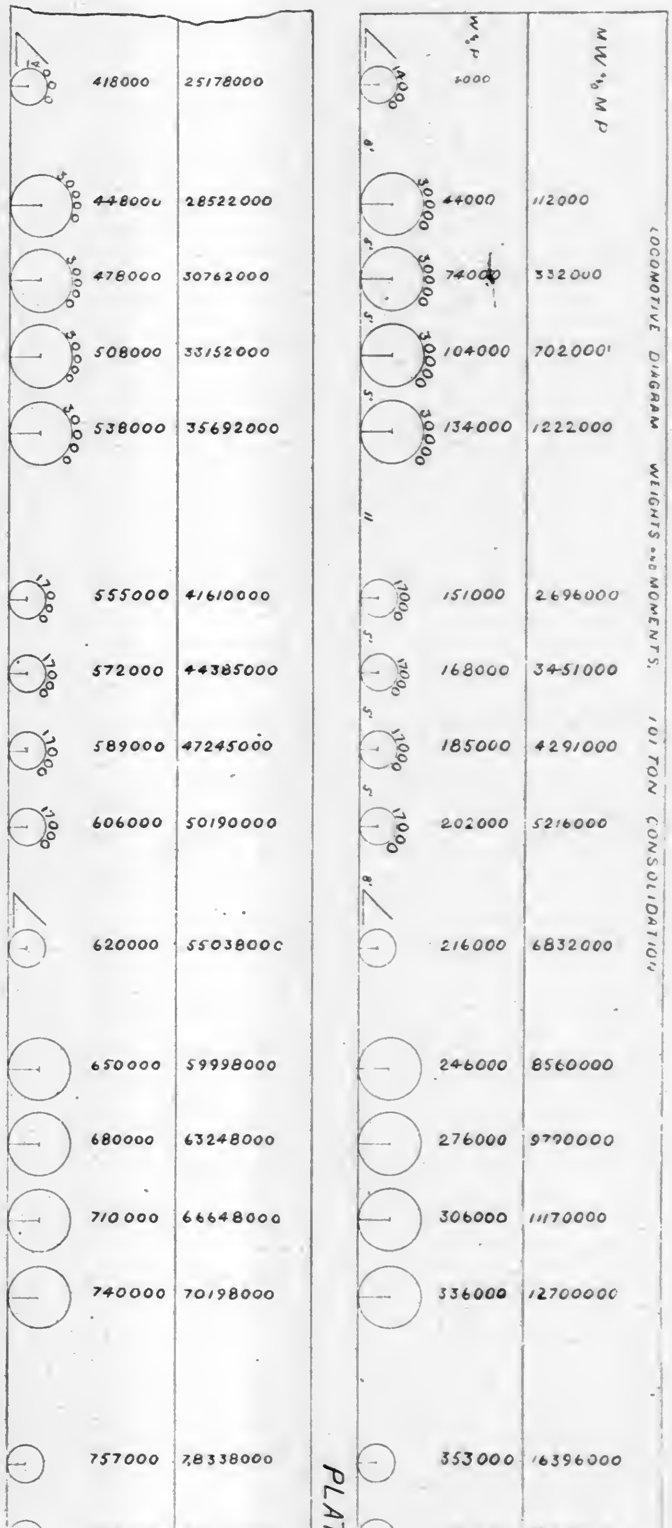


PLATE 100

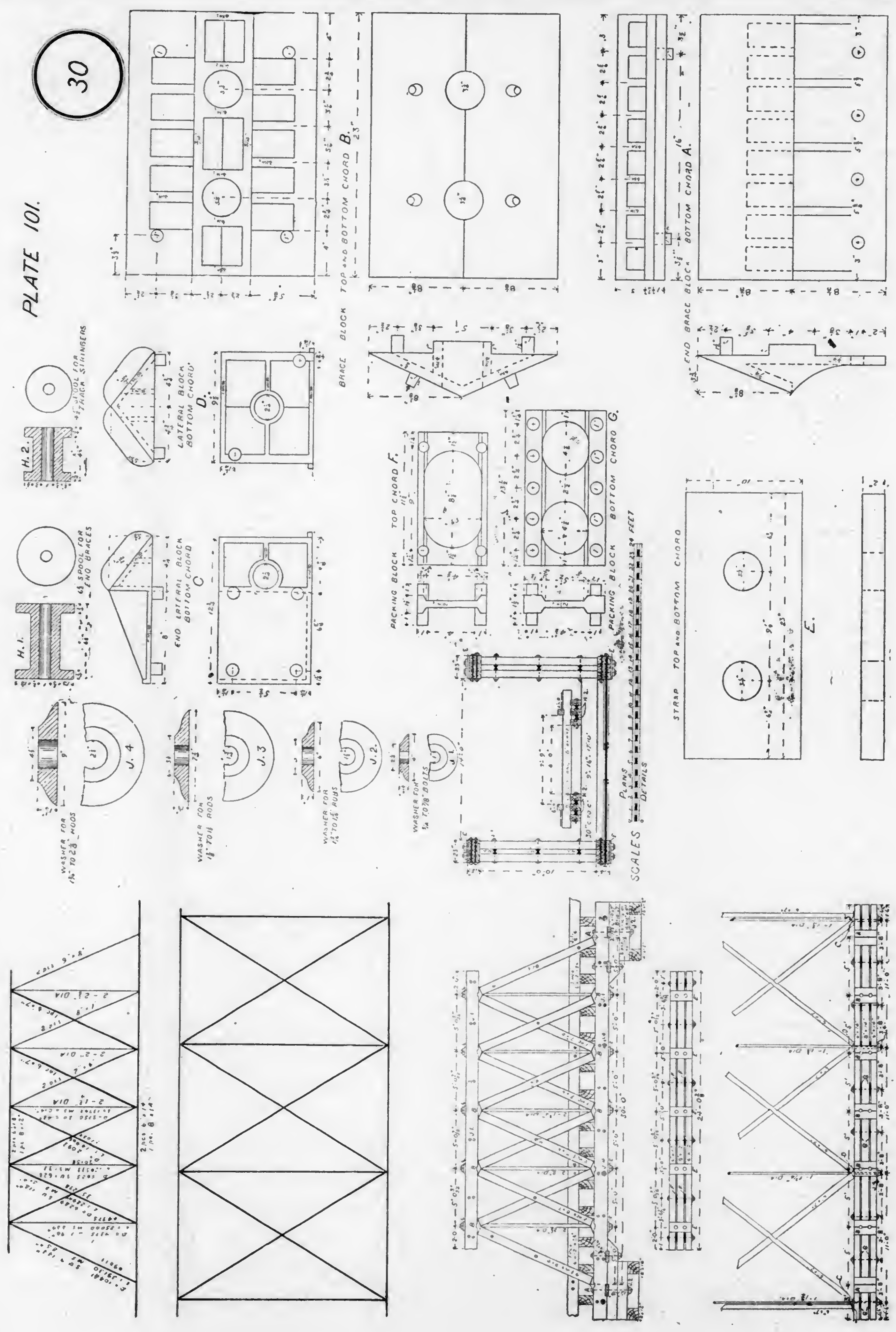

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PLATE 101.
TOP AND BOTTOM CHORD B.
BOTTOM CHORD A.
BRACE BLOCK
END BRACE BLOCK
LATERAL BLOCK BOTTOM CHORD D.
END LATERAL BLOCK BOTTOM CHORD C
SPOOL FOR TRACK STRINGERS
SPOOL FOR END BRACES
H.1.
H.2.
TOP CHORD F.
PACKING BLOCK
BOTTOM CHORD G.
PACKING BLOCK
STRAP TOP AND BOTTOM CHORD E.
J.1
J.2.
J.3
J.4
SCALES
PLANS
DETAILS
FEET

No. 39. Bill of Material for Bridge of 30 Ft. Span. Plate 101.

Wood.

No. of Pieces.	Description.	Size.	Length.	Ft. B. M.	Kind of Wood.
4	Top Chord...	6 in. × 12 in.	24 ft. 0⅜ in.	576	Yellow Pine.
2	" " ...	8 in. × 12 in.	24 ft. 0⅜ in.	384	" "
4	Bottom Chord	6 in. × 14 in.	36 ft. 0 in.	1,008	" "
2	" "	8 in. × 14 in.	36 ft. 0 in.	672	" "
8	Braces...	9 in. × 8 in.	16 ft. 0 in.	768	" "
8	"	8 in. × 7 in.	16 ft. 0 in.	600	" "
8	"	7 in. × 6 in.	16 ft. 0 in.	448	" "
8	Counters... .	7 in. × 6 in.	16 ft. 0 in.	448	" "
6	Laterals......	7 in. × 6 in.	17 ft. 6 in.	378	" "
2	"	7 in. × 6 in.	14 ft. 0 in.	98	" "
8	Bolsters......	6 in. × 10 in.	7 ft. 0 in.	280	" "
4	"	8 in. × 10 in.	7 ft. 0 in.	128	" "
8	Bridge-seats..	6 in. × 10 in.	5 ft. 0 in.	200	" "
4	" " ..	8 in. × 10 in.	5 ft. 0 in.	134	" "
4	Sills..........	12 in. × 12 in.	18 ft. 0 in.	864	Spruce or Pine
14	Floor-beams..	9 in. × 16 in.	18 ft. 0 in.	3.024	" " "
6	Stringers.....	6 in. × 12 in.	36 ft. 0 in.	1,296	" " "
33	Ties.....	8 in. × 8 in.	12 ft. 0 in.	. ...	Oak.
2	Guards.......	6 in. × 6 in.	36 ft. 0 in.	216	Spruce or Pine
4	Plank........	2 in. × 8 in.	36 ft. 0 in.	192	" " "
8	Blocks.... ...	2 in. × 8 in.	2 ft. 0 in.	22	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2½ in.	12 ft. 10 in.	12	Bolster.	1¼ in.	3 ft. 3 in.
8	"	2 in.	12 ft. 10 in.	14	Floor-beam.	1¼ in.	4 ft. 4 in.
4	"	1¾ in.	12 ft. 10 in.	24	Stringers.	¾ in.	2 ft. 6 in.
4	Laterals.	1¾ in.	18 ft. 6 in.	14	Ties.	¾ in.	2 ft. 6 in.
56	Chord-bolts.	¾ in.	2 ft. 0¼ in.	14	Guards.	¾ in.	1 ft. 3 in.
20	Brace-bolts.	¾ in.	2 ft. 0¼ in.	24	Spikes.	½ in.	9 in.
12	Bolster.	1¼ in.	2 ft. 2 in.				

Washers: 300 of pattern *I1*; 76 of *I2*; 8 of *I4*.

Castings.

Pieces: 4 of pattern *A*; 20 of *B*; 4 of *C*; 4 of *D*; 20 of *E*; 24 of *F*; 40 of *G*; 12 of *H1*; 16 of *H2*.

No. 40. Bill of Material for Bridge of 36 Ft. Span. Plate 102.

Wood.

No. of Pieces.	Description.	Size.	Length.	Ft. B. M.	Kind of Wood.
4	Top Chord....	6 in. × 12 in.	28 ft. 0½ in.	720	Yellow Pine.
2	" "	8 in. × 12 in.	28 ft. 0½ in.	480	" "
4	Bottom Chord	6 in. × 14 in.	42 ft. 0 in.	1,176	" "
2	" "	8 in. × 14 in.	42 ft. 0 in.	784	" "
8	Braces	9 in. × 8 in.	16 ft. 0 in.	672	" "
8	"	8 in. × 7 in.	16 ft. 0 in.	600	" "
8	"	7 in. × 7 in.	16 ft. 0 in.	528	" "
8	Counters.....	7 in. × 6 in.	16 ft. 0 in.	448	" "
6	Laterals......	6 in. × 7 in.	20 ft. 0 in.	420	" "
2	"	6 in. × 7 in.	14 ft. 0 in.	98	" "
8	Bolsters......	6 in. × 10 in.	8 ft. 0 in.	320	" "
4	"	8 in. × 10 in.	8 ft. 0 in.	214	" "
8	Bridge-seats..	6 in. × 10 in.	6 ft. 0 in.	240	" "
4	" " ..	8 in. × 10 in.	6 ft. 0 in.	160	" "
4	Sills..........	12 in. × 12 in.	18 ft. 0 in	864	Spruce or Pine
14	Floor-beams..	9 in. × 16 in.	18 ft. 0 in.	3 024	" " "
6	Stringers......	6 in. × 12 in.	42 ft. 0 in.	1,512	" " "
40	Ties..........	8 in. × 8 in.	12 ft. 0 in.	.....	Oak.
2	Guards.......	6 in. × 6 in.	42 ft. 0 in.	252	Spruce or Pine
4	Planks.......	2 in. × 8 in.	42 ft. 0 in.	224	" " "
8	Blocks.......	2 in. × 8 in.	2 ft. 0 in.	22	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2⅝ in.	12 ft. 10 in.	12	Bolster.	1¼ in.	3 ft. 3 in.
8	"	2¼ in.	12 ft. 10 in.	14	Floor.	1¼ in.	4 ft. 4 in.
4	"	1¾ in.	12 ft. 10 in.	24	Stringer.	¾ in.	2 ft. 6 in.
4	Laterals.	1¾ in.	18 ft. 6 in.	14	Tie.	¾ in.	2 ft. 6 in.
56	Chord-bolts.	¾ in.	2 ft. 0¼ in.	14	Guard.	¾ in.	1 ft. 3 in.
20	Brace-bolts.	¾ in.	2 ft. 0¼ in.	24	Spikes.	½ in.	9 in.
12	Bolster.	1¼ in.	2 ft. 2 in.				

Washers: 300 of pattern *I1*; 76 of *I2*; 8 of *I4*.

Castings.

Pieces: 4 of pattern *A*; 20 of *B*; 4 of *C*; 4 of *D*; 20 of *E*; 24 of *F*; 40 of *G*; 12 of *H1*; 16 of *H2*.

standard designs in the possession of the Author, but considering the ever-increasing loads that are used in practice, it has not been considered so excessive as to be uneconomical.

The span of the bridge (which will in every case be found clearly marked upon the plan enclosed in a circle) is the number of panels multiplied by the length of one panel. In dimensioning the members, the following specifications will be followed:

Rods.—The allowable stress per square inch of sectional area not to exceed 8,000 lbs.

The ends of all rods to be upset so that the sectional area at the bottom of the thread shall exceed that of the main part of the rod.

Bottom Chord.—Allowable stress per square inch for tension not to exceed 800 lbs. of effective area, due allowance being made for bolt holes, etc.

In the shorter spans the amount of tension brought upon the bottom chord requires such slight sectional area, as compared with that necessary to resist the cross-strain due to the floor beams, that it may be entirely omitted in the calculation, and the bottom chord proportioned simply to support the floor beams and give sufficient stiffness and rigidity to the structure.

The top chord and braces are proportioned according to the following formula:

$$W = \frac{700}{1 + 1.5\left(\sqrt{1 + \frac{l^2}{900d^2}} - 1\right)}$$

Here $W =$ allowable stress in pounds per square inch of sectional area.

$l =$ length in inches of member between square ends.
$d =$ depth of member in inches.

This formula is intended simply for use in the dimensioning of the compression members of Howe truss bridges, and would not apply to long, slender columns.

Owing to the manner in which these bridges are designed, the total width of the braces and top chord always exceeds their depth, and as they are always firmly bolted together flexure can only take place in the plane of the truss.

As the counter-braces are introduced in every panel and the main braces and counters bolted together at their centers, the dangerous length of the brace is practically much shortened, the length l, used in the formula, being the total length between the square ends of the braces, where they rest upon the brace-blocks.

The dead load used is taken at 1,500 lbs. per running foot for pony trusses. The floor system, shown in Plates 101 and 102, is the standard in use upon the Atchison, Topeka & Santa Fé Railroad. There will be given, in following chapters, a number of plates containing different types of floor systems, with complete bills of material for each, so that the engineer may use in connection with the plans of the bridge proper any type of floor system he desires.

Upon the strain diagram will be found the maximum strains due to the dead and live load, also, *m, s*, the minimum allowable section according to the above strain specifications; *s, u*, the section used in dimensioning the members, the difference being the allowance made for impact, etc. In the short-span bridges a great allowance has been made, as will be seen by an examination of the strain diagram.

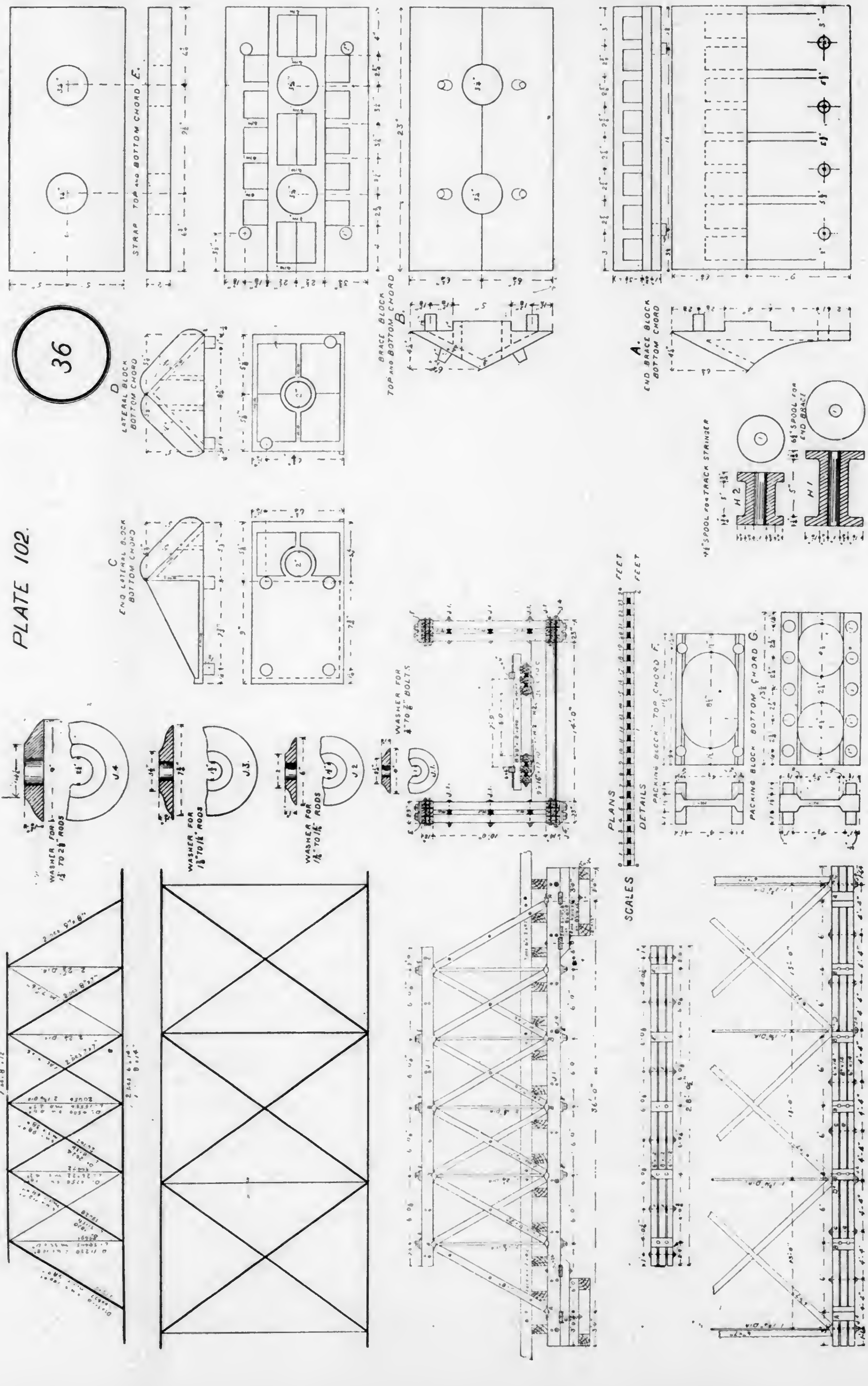

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PLATE 102.
STRAP TOP AND BOTTOM CHORD E.
BRACE BLOCK TOP AND BOTTOM CHORD B.
A. END BRACE BLOCK BOTTOM CHORD
D LATERAL BLOCK BOTTOM CHORD
C END LATERAL BLOCK BOTTOM CHORD
SPOOL FOR TRACK STRINGER
SPOOL FOR END BRACE
H 2
H 1
J.4
J.3
J.2
J.1
PACKING BLOCK TOP CHORD F.
PACKING BLOCK BOTTOM CHORD G.
SCALES
PLANS
DETAILS
FEET

The actual strains coming upon the top and bottom chords from compression and tension alone are so slight in these short-span bridges, as compared with the sectional area necessary for stiffness and cross-strain, that they have been omitted upon the strain diagram ; also, for the same reason, the strains upon the counter-braces and the strains upon the lateral bracing.

This series of bridge plans will include spans from 30 ft. to 150 ft., varying in length by 5 ft. or 6 ft. ; also, both deck and through bridges, with complete bills of material.

Each plan will be complete in itself, including every detail necessary for the construction of the bridge. This has led to the repetition of the drawings of some of the castings and details, but the Author considers that the advantage derived from having each separate bridge plan complete in itself, without the necessity of referring to any plan other than the particular one used, will more than counterbalance the extra amount of labor and expense in their preparation.

The graphical and analytical methods used in the calculation of the strain diagrams will be given in full.

Any engineer finding errors in these plans or bills of material, or having any suggestions to offer that will in any way increase their value to the engineering profession, will confer a great favor upon the Author by communicating at once with this Journal.

NOTE.

In regard to the plans of Overhead Crossings for Highways, which were left in a most incomplete condition in the February number, the Author begs leave to state that he was unable to procure some standard plans of such bridges in time to have them reproduced for this number ; but that later a full series of these plans will be given.

(TO BE CONTINUED.)

THE ESSENTIALS OF MECHANICAL DRAWING

By M. N. Forney.

INTRODUCTION.

Some extenuating reason is demanded for writing another series of articles on Mechanical Drawing after the many which have already appeared, and in addition to all the books on the subject which have been published. This reason is that it has seemed to the writer that, in all of the books which have come under his observation, the subject has been made more difficult for the learner—especially if he is a person of limited education—than there is any need for. Many of them give examples and problems so difficult that all but the most indefatigable learners become discouraged. Most of these problems are of little practical value to a mechanic or draftsman and there is very seldom any occasion to make use of them. Take, as an example, the drawing of a projection of a screw-thread. Nearly all the books on mechanical drawing explain how this is done, and very often in an early chapter. In the first part of one of the books of this kind it is explained how to draw a pair of miter or bevel wheels *in an oblique position*—one of the most difficult problems of mechanical drawing that could be propounded, and one which few draftsmen ever have occasion to work out. Now it is admitted that an accomplished and thoroughly educated mechanical engineer and draftsman should have a knowledge of these and even of more difficult branches of his art, but they should be reserved for a later period, and should not form a part of elementary instruction to those who, in the beginning, want to learn only the Essentials of Drawing. In the following articles it will be the aim of the writer to explain these *Essentials* as simply and clearly as possible, and in the first part of the book all difficult problems which have no application in making or understanding ordinary mechanical drawings will be omitted.

In the interesting autobiography of James Nasmyth, the inventor of the steam hammer, that distinguished engineer says : "Mechanical drawing is the alphabet of the engineer. Without this the workman is merely 'a hand.' With it he indicates the possession of 'a head.' . . . Throughout my professional life I have found this art to be of the utmost practical value." Drawing, he says, is "graphic eloquence," and "is one of the highest gifts in conveying clear and correct ideas as to the forms of objects, whether they be those of a simple and familiar kind or of some mechanical construction."

The writer's experience, and the testimony of mechanics and engineers of distinction, confirms the opinion of Mr. Nasmyth that "*graphic language is one of the most valuable gifts which a man who has to do with practical subjects can possess.*" It is also true that an amount of instruction just sufficient to enable mechanics to understand, or, as they express it, "read" drawings, will be of great service to them, and will increase their usefulness to their employers. Even to persons who are not engaged in mechanical pursuits, a knowledge of the elements of mechanical drawing would be of more value than any other one thing, which can be learned so easily. Every farmer, at some time, has occasion to make a plot of a piece of land, a plan for a barn or pig-sty ; a merchant must lay out shelving for his shop ; a clergyman would like to plan a church, design a bookcase or a tombstone, or his wife will want to send the dimensions and shape of her parlor for a new carpet.

The aim of the following articles will be to make the study of mechanical drawing easy, so that its *essentials* can be comprehended by all who can read and write and cipher.

CHAPTER I.

To begin the study of Mechanical Drawing the learner should provide himself with the following instruments and materials :

Drawing Board.
T-Square.
Triangle with 30, 60 and 90-degree angles.
Triangle with 45, 45 and 90-degree angles.
Two-foot Rule.
Drawing Scale.
Protractor.
Joint Compasses.
Spring Compasses.
Point, Pencil-holder and Pen for the Compasses.
Pen-holder.
Half-dozen Drawing Tacks.
Half-dozen Sheets of Paper.
H H H H H H Pencil.
Piece of Fine Sand-paper.
Stick of India Ink.
Piece of India Rubber.

THE DRAWING BOARD.

The most suitable sized board, for a learner, is 32½ in. long and 21½ in. wide, for the reason that the paper best suited for his use is made in sheets 32 by 21 in., and when these are fastened to the board there should be a little margin outside of the edges of the paper. Such a board ought to be made of white pine "stuff" 1¼ in. thick, planed down to whatever thickness it will "go" when it is "trued up." The lumber which is used should be well seasoned "clear" or free from knots and resinous sap. There should be a cleat at each end of the same thickness as the board and 1½ in. wide, tongued and grooved, and nailed to the ends of the board with wire nails about 3¼ in. long, as shown in figs. 1 and 2. The nails should be driven in until their heads are about ⅛ in. below the surfaces of the cleats, and the holes should be puttied up. If the board is made of more than one piece the edges should be glued together, but the tongues and grooves for the cleats should not be glued. If they are the board is liable to split if it shrinks. A board made in this way can be smoothed off on both sides, so that either or both can be used for drawing on, which is often a convenience. If a smaller sized board is used it will not have weight enough to hold its position. There is, however, no special advantage in the particular size given. Almost any sized board will answer for a student who is eager to learn.

The ends of the board should be made straight and true. It is preferable to have them slightly concave rather than convex or "rounding." The long edges should be as near square with the ends as they can conveniently be made. Great accuracy in this respect is not essential, as the T-square should not be used on more than one edge of the board in drawing.

T-SQUARE.

The T-square should have a blade 35 in. long, about 2½ in. wide, and $\frac{3}{32}$ in. thick. The best ones are made of mahogany with ebony edges, but cherry, apple or pear wood, either with or without ebony edges, all answer very well for T-squares, straight edges and triangles. The head or stock of the T-square may be made of mahogany or any of the other woods mentioned. It ought to be $\frac{5}{16}$ in. thick, 10 in. long by 2½ in. wide at its greatest breadth, and of the shape shown in fig. 3. The blade

is fastened on the head (not let in) with screws and washers under them. If the blade is let into the head, so as to be flush with its surface, the head will project above the surface of the board when the T-square is in use, and will be in the way in using a scale or triangle near the left-hand edge of the board.

Fig. 1.

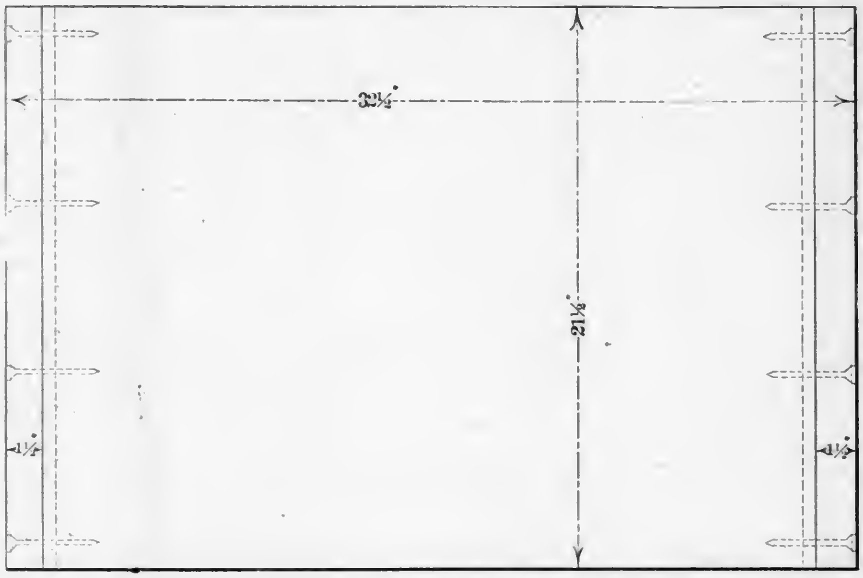


Fig. 2.

The copper washers which are made for leather machine belt rivets answer very well for fastening the blade of a square to its head.

The upper edge of the blade—which is the one used in drawing—should be at an equal distance from the two ends of the head when they are fastened together, as shown in fig. 3. The usual practice is to attach the blade to the middle of the head.

Fig. 3.

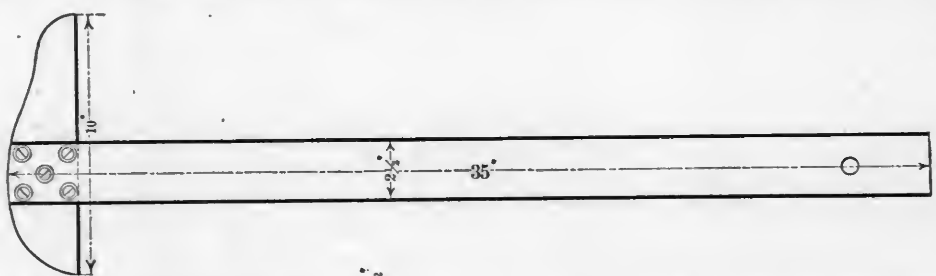


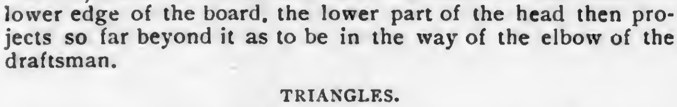
Fig. 4.

The objection to this is that when the blade is used near the lower edge of the board, the lower part of the head then projects so far beyond it as to be in the way of the elbow of the draftsman.

TRIANGLES.

The best triangles are made like those shown in figs. 5 and 6, of any of the woods named above for T-squares, and with ebony edges, but the latter is not essential. Very good ones without ebony edges, made of pear or apple wood, can be bought of the dealers in drawing materials, and still cheaper ones are made of one piece of wood with a round hole bored in the middle. These are not quite as satisfactory as the others, but very good work can be done with them.

The most convenient forms and sizes of triangles are those shown in figs. 5 and 6. One of them, fig. 5, should have 30, 60 and 90-degree angles with an 8-in. base; the other, fig. 6, should have 45, 45 and 90-degree angles and 4-in. base. They



should both be $\frac{3}{32}$ in. thick. The thickness is a matter of some importance; if they are either too thin or too thick they are inconvenient to work with. The reasons why these angles are preferable to any other will appear further on.

If the necessity for close economy is imposed upon the learner, he can make his own drawing board, T-square, and triangles, if he is a mechanic, or have them made, if he can obtain the services of any kind of a carpenter who is a good workman. To enable him to do this, the following method of laying off a 30, 60 and 90-degree triangle is given: Draw a circle *a b c d e f*, fig. 5. Then subdivide this circle by its radius into six equal divisions, and draw a line through the center of the circle, and two opposite points of division, *e* and *b*. From one of these points, *b*, draw a line to the next adjoining point, *c*, and then connect the latter with a line drawn to *e*, the point of beginning. Those lines will form the sides of the triangle with the required angles.

To make a triangle with two angles of 45 degrees, draw a circle *a b c d*, fig. 6, and a diameter *a c*. Then subdivide the semicircle *a b c* at *b*, and connect *a* and *b* and *b* and *c*. The triangle *a b c* will then have the required angles.

SCALES.

A 6 or 12-in. triangular boxwood scale, represented in fig. 7, is perhaps the best for a learner. They have two different scales on each edge, so that there are 12 altogether. For mechanical drawing they are usually graduated to $\frac{1}{16}$, $\frac{1}{8}$, $\frac{1}{6}$, $\frac{1}{5}$, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{2}$, and 3 in. = 1 foot. In addition to this scale a two-foot rule will be needed to make measurements and drawings full size. Any ordinary form will answer, but what is called an "engineer's pocket rule," fig. 8, is lighter and more convenient than the ordinary kinds.

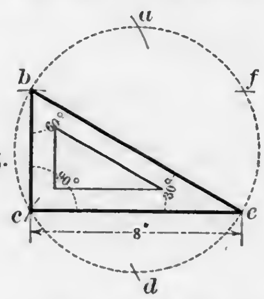
PROTRACTOR.

A paper protractor like that represented in fig. 9 will be all that a beginner will need. These are printed on stiff paper or cardboard. In fact, the engraving will be all that the student needs in beginning his studies.

COMPASSES.

A pair of from 4 to 6-in. joint-compasses, similar to that shown by fig. 10, will be needed with a removable point, pencil-holder and pen for drawing circles or parts of circles with radii of from about ¼ in. up to 8 or 10 in. For small circles, a spring-compass, similar to that shown in fig. 11, should be provided. These engravings represent compasses designed by the writer. The point *c*, pencil-holder *d*,

Fig. 5.



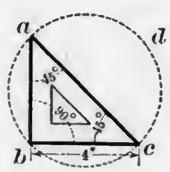


Fig. 6.

and pen *e* are made so that they can be used in either instrument, and also in the beam-compasses shown in fig. 19. The distance from the joints at *a* and the points at *b* are made shorter than usual, so that a larger circle can be drawn with compasses of a given size than is possible with those ordinarily sold. A pen-holder, fig. 12, is also provided, so that the pencil-holder and pen can each be used for drawing straight lines. This is often a convenience, especially with the pen when it is supplied with ink. As shown in the engravings, it can be quickly taken from the compasses and attached to the holder, fig. 12, without re-

Fig. 7.

moving the ink, and can thus be used for drawing either circles or straight lines. When a separate pen must be used for the compasses in drawing circles or curved lines, and another for drawing straight lines, in changing from one to the other the pen in use must always be cleaned and the other supplied with ink, which consumes valuable time.

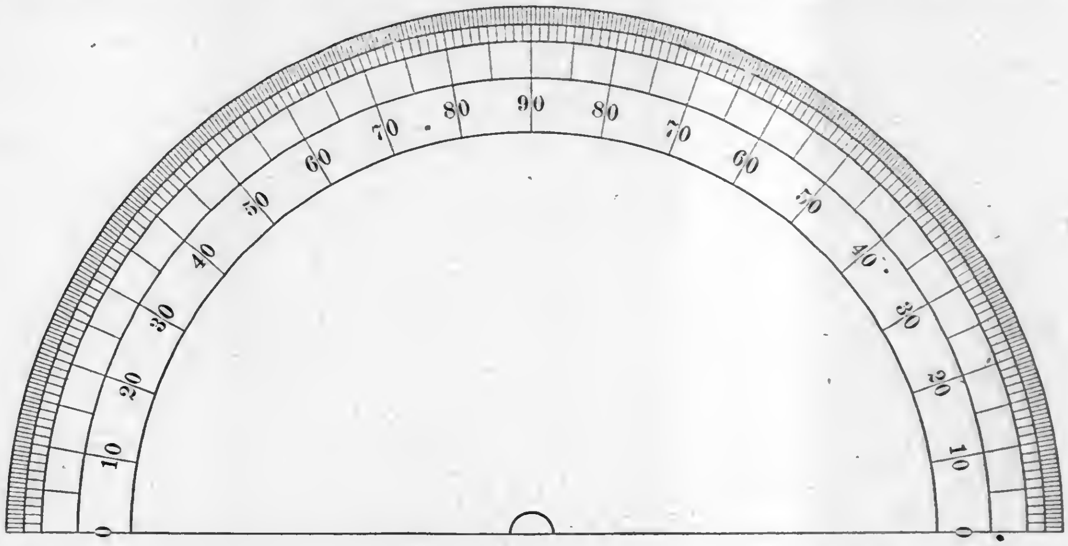


Fig. 9.

The joint-compasses has a needle point at *b* to prevent the point from making a large hole in the paper, when many circles or curved lines must be drawn from one center. As the spring-compasses is smaller and lighter and is used only for small circles, it is not liable to enlarge the centers, and therefore does not require a needle point. Both the joint and spring-compasses can be used as dividers by substituting the point *c* in place of the pencil-holder or pen.

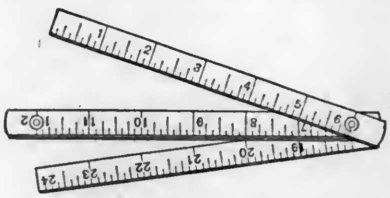


Fig. 8.

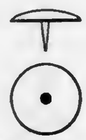


Fig. 13.

A great variety of forms and qualities of drawing instruments are sold by dealers. If the learner can possibly afford it, he is advised to buy only the best quality. If properly taken care of they will last him a lifetime. The aim in designing the instruments illustrated was to make as few as possible answer the requirements of a student or draftsman. The joint-compasses should be made of German silver, and the handle *f*, fig. 11, of the spring-compasses, and *g*, fig. 12, for the pen, of ivory.

DRAWING TACKS.

Fig. 13 represents two full-size views of a suitable size of drawing tack for holding the paper on the board. The points should be only about $\frac{5}{32}$ in. long and about $\frac{3}{100}$ in. in diameter, or about as large as an ordinary toilette pin. If drawing tacks are too big they are hard to press into the board and difficult to pull out. Generally the shanks or parts which enter the board are made so large in diameter that they leave very annoying holes. The shanks of the best tacks are screwed into the heads, which are made of German silver. If the shanks are merely riveted in the heads, they are apt to get loose in the act of pressing them into the board, with the result that one end of the shank enters the board and the other the operator's thumb.

PAPER.

A great variety of papers for various kinds of drawing can now be obtained of dealers from whom and from a little experience the draftsman will learn more than could be taught him by the writer. The learner is advised to get a half dozen or more sheets of what is known as linen record paper, which are made 21 by 32 in. in size. This paper is not costly, does not tear easily, it takes both pen and pencil-lines readily, and will stand a reasonable amount of abrasion from india-rubber. It is not very well suited for coloring with a brush, for which a different kind of paper should be used, as will be explained hereafter. Almost any kind of paper can, however, be used to draw on. A smooth pine board will do if nothing better can be obtained.

PENCIL.

Both Dixon's American Graphite or Faber's HHHHHH hexagon pencils are very good.

It is of the utmost importance in mechanical drawing that the representations of the objects should be accurate and precise, and therefore pencil lines should be drawn fine and distinct. For this reason hard pencils must be used, which will retain a sharp point longer than soft ones will. Both Dixon's

Fig. 10.

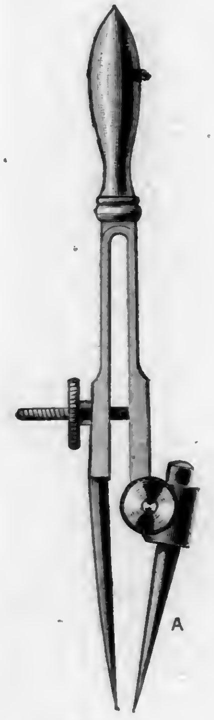


Fig. 11.

Fig. 12.

American Graphite and Faber's HHHHHH hexagon pencils are of about the requisite hardness.

In order to maintain a sharp pencil point as long as possible, it should be made flat, so as to be long in the direction in which it is moved and worn, and therefore the point should be sharp-

ened to a form somewhat like a chisel edge rounded, as shown at *a* and *b* in figs. 14 and 15. If the pencil is round or octagonal, it is not easy to get this flat point in the right position every time the pencil is taken up. For this reason it is a good plan to have the wood of the pencil planed down so that it will be flat, as shown in figs. 14, 15 and 16. In doing this care should be taken that the wood is planed away on each side of the edges which are glued together, and that the glued joint should extend lengthwise through the flattened section of the pencil, as shown by the line in fig. 16, which is an end view of a pencil planed down as described. If the joint runs crosswise of the section of the pencil, there may not be glued surface enough left to hold together, and the wood will then split apart in the joint.

Fig. 14.

Fig. 15.

Fig. 16.

A piece of fine sand-paper or a small and rather fine flat file about $\frac{5}{16}$ in. wide and $3\frac{1}{2}$ in. long should be used for sharpening pencils.

INDIA INK.

Ordinary writing ink should not be used for mechanical drawings, as it corrodes the instruments, is difficult to erase, and is rarely black. India ink alone should be used. The student will find a stick or cake of this ink is more portable and generally preferable to that prepared in liquid form. There is a great difference both in price and in quality of the various kinds of India ink. It consists essentially of lamp-black in *very fine condition*, baked up with a glutinous substance. If the lamp-black has not been reduced to a very fine condition, or if there is any gritty substance in it, the ink will not flow freely from the pen. Various tests for this ink have been given in different books, but probably the best the student can do is to buy a stick and try it, and if it is not good try some other kind. India ink is liable to crack in drying after it has been wet, or from exposure

Fig. 17.

Fig. 18.

Fig. 20.

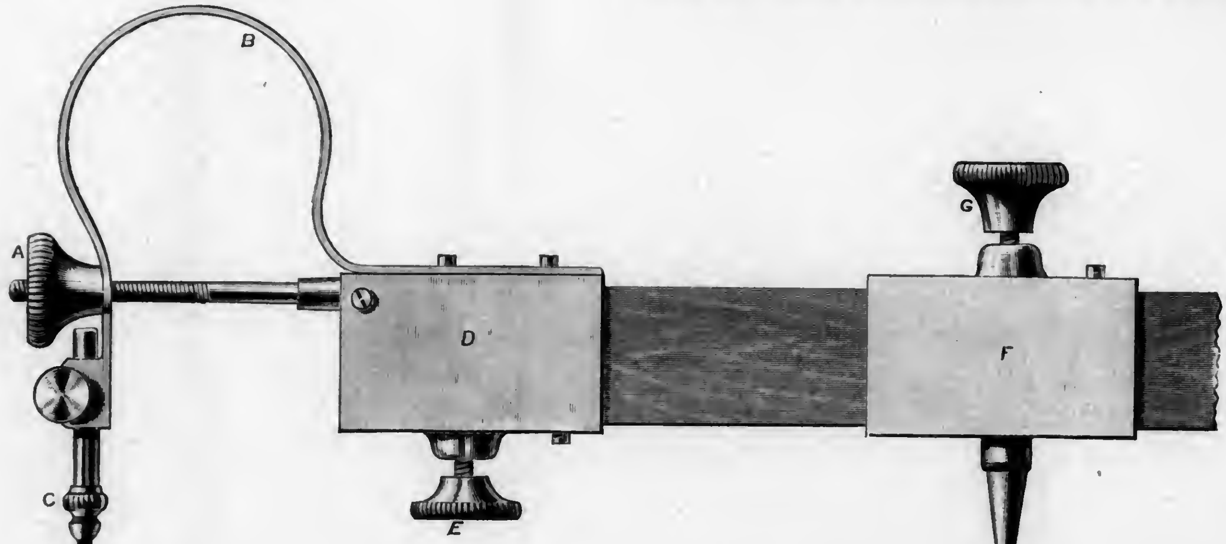


Fig. 19.

to the air. For this reason a round stick is the most convenient form. This can be protected from the air by cutting a piece of thick and strong manilla paper of the right size to roll around the stick of ink twice. The paper should first be thoroughly moistened and one side should be covered with liquid glue or gum-arabic, which has been dissolved in water to the consistency of thick molasses. The paper should then be rolled around the stick of ink and thus glued or gummed to it and to itself, where the folds overlap each other. When the paper dries it will shrink and thus hold and protect the stick of ink from moisture, air and liability to breakage. As the end of the stick is worn by rubbing, the paper can be cut away slightly, so that particles of it will not be rubbed up with the ink.

INDIA RUBBER.

The best material for erasing pencil lines is what is known as "velvet" rubber. Pieces ½ by ½ by 2½ in. long are a convenient size.

ADDITIONAL INSTRUMENTS.

The instruments and materials which have been enumerated and described are all that are essential in beginning the study and, in fact, in practising mechanical drawing. There are, however, some others which the student would do well to get if he can conveniently afford it. He will find that considerable time will be lost and some annoyance incurred in changing the pencil-holders and points in the compasses, if these instruments are used both for drawing circles and as dividers for laying off dimensions. For this reason he will find that a pair of

JOINT AND SPRING DIVIDERS,

shown in figs. 17 and 18, will make frequent changes of the point and pencil-holder unnecessary, and will therefore be a great convenience.

He will also find that it is sometimes essential to draw circles or parts of circles with a larger radius than he can command with his joint-compasses. To meet this requirement a

BEAM-COMPASSES

will be needed. The one shown in fig. 19 has also been designed by the writer, and is arranged to take the same point, pencil-holder and pen that is used with the joint and spring compasses, figs. 10 and 11. The beam-compasses cansist of a permanent head *A*, which is fastened to the wooden bar or stick *W* by the set screw *E*. The spring *B* is fastened to the head *A*, and has a socket at *S*" to receive the pencil-holder and pen. The wooden bar *W* can be made of any length required within obvious limits. The movable head *F* has a point *E*, and slides on the bar *W*, and can be clamped by the screw *G* in any desired position, and the distance between the point *E* and the pen or pencil at *F* can be made whatever is needed. It is not easy, however, to regulate this distance with great precision by the screw *D* alone. For this reason the spring is arranged with a screw and nut *A*, by means of which the position of the pen or pencil can be adjusted with great accuracy. Wooden bars of different lengths can be provided, so that curves of any radii up to obvious limits can thus be drawn.

INK CUPS.

A nest of cups or "cabinet saucers," fig. 20, are also very convenient for rubbing ink and colors in, the use of which will be explained further. Those 2⅜ in. outside diameter are a convenient size.

(TO BE CONTINUED.)

Recent Patents.

I.—PITKIN'S COMPOUND LOCOMOTIVE.

MR. A. J. PITKIN, Superintendent of the Schenectady Locomotive Works, has patented an improvement in compound locomotives, the object of which is first, to regulate automatically the admission of live steam to the low-pressure cylinder in starting; and, secondly, automatically to cut off the passage of live steam to the low-pressure cylinder by the action of the exhaust-steam from the high-pressure cylinder upon an intercepting-valve between the high and low-pressure cylinders. This valve is opened automatically for the passage of live steam direct to the low-pressure cylinder to start the engine, and after the engine is started the valve is closed by the pressure of the exhaust-steam from the high-pressure cylinder. The direct access of live steam to the low-pressure cylinder is thus cut off by the action of the intercepting-valve, and, when the throttle-valve is closed, the intercepting-valve remains closed until live steam is again admitted to the high-pressure, when the operations which have been described are again repeated.

Fig. 1 is a vertical transverse section through the cylinders and smoke-box; fig. 2 is a vertical longitudinal section through the intercepting-valve *G*, of fig. 1, and the low-pressure cylinder *E*; fig. 3 is a section through the regulating-valve on the line

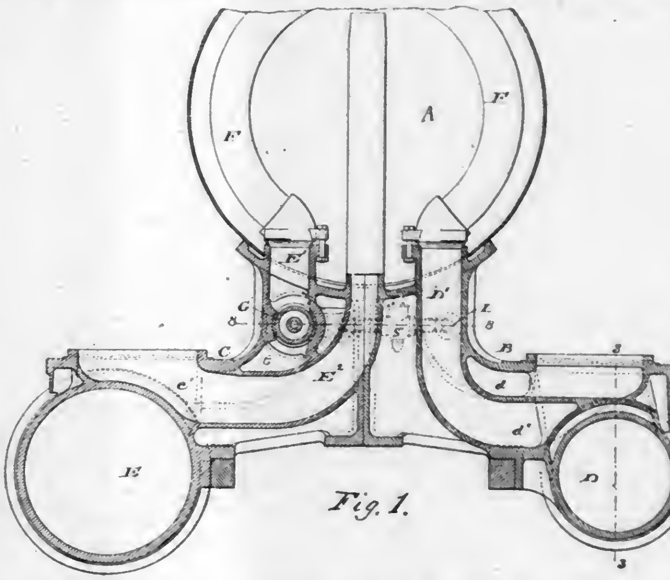


Fig. 1.

6 6 of fig. 2, and fig. 4 a similar section through the regulating-valve on the line 5 5; and fig. 8 is a horizontal section through the intercepting valve and saddles on the line 8 8 of fig. 1.

The engine has two cylinders located in the usual way. *D*, fig. 1, is the high-pressure and *E* the low-pressure cylinder. The saddles *B C* are also constructed in a similar way to the ordinary practice, and have the usual induction and eduction-ports. The exhaust-port *d'*, of the high-pressure cylinder, is connected by a pipe or conduit *D'* with an arched or horseshoe-

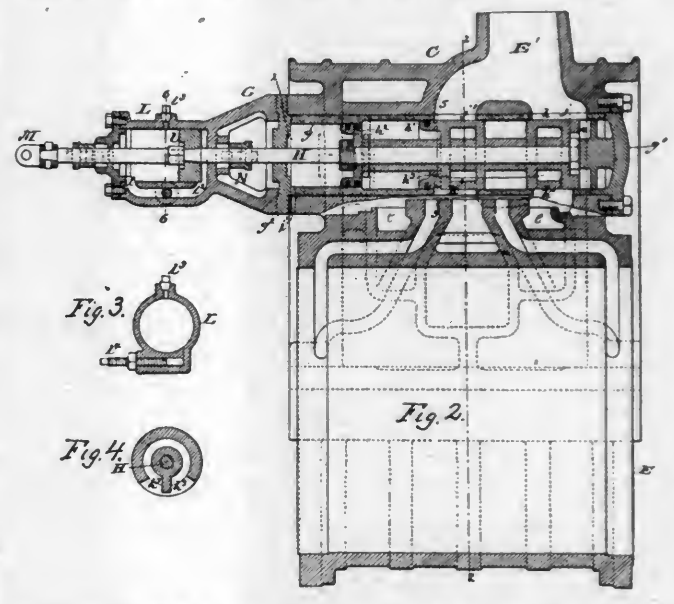


Fig. 3. Fig. 4. Fig. 2.

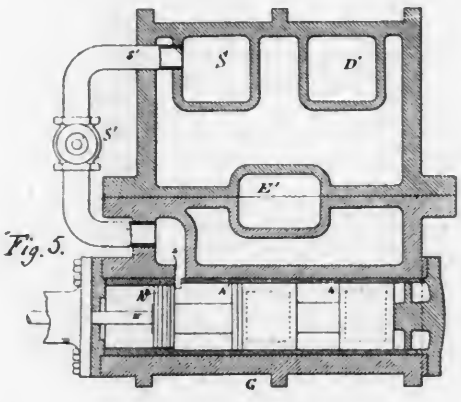
shaped pipe *F F*, which passes around the smoke-box in the ordinary way, and forms a superheater and receiver, and is connected with the pipe *E'*, which communicates through the intercepting-valve *G* with the induction-ports *e e*, figs. 1 and 2, of the low-pressure cylinder.

The intercepting-valve *G* is of the piston type and is contained in a chamber cast in the saddle *C*. This has a bushing *g*, fig. 2, and two removable heads g^1 and g^2. Another cylindrical chamber *L* is attached to the head g^2, and a piston-rod *H* works through a stuffing-box *N* and carries four pistons h h' h^2 and *l*. The pistons *h* and *h'* are separated a sufficient distance for the passage of steam between them, from the pipe *E'* to the induction-ports *e e* which supply the low-pressure cylinder with steam. The piston h^2 is nearer the other or forward end of the valve-cylinder *g*, and is of smaller diameter than the others, the bore of the cylinder being reduced in that portion traversed by this

piston, in order that the other pistons may exert a preponderating pressure on the intercepting-valve at the proper time, as hereinafter explained. This part of the cylinder is provided with a live-steam induction-port *i*, and also with an eduction-port *i'*, opening direct to the atmosphere for the escape of the steam or condensed water from this portion of the cylinder. The piston h^2 is far enough from the piston *h* not to interfere with the admission of steam through *h'* to the interior of the cylinder or bushing *g*. The central piston *h'* is provided with ports or openings h^3, fig. 4, through which live steam may pass to the low-pressure cylinder. Openings or ports *j j'* in the cylinder or bushing match with corresponding openings or ports *k k'* in the induction-port *e* of the low-pressure cylinder to admit the passage of the steam through the intercepting-valve.

The operation of the engine is as follows: When it stops and remains with the valve open for the passage of exhaust-steam from the high to the low-pressure cylinder, in which position the intercepting-valve prevents the entrance of live steam through it direct to the low-pressure cylinder. When the throttle-valve is opened, live steam enters the high-pressure cylinder through one branch *s* of the live-steam pipe *S*, fig. 5, while live steam simultaneously passes through the other branch *s'* of this pipe, to the pressure-reducing device *S'*, when one is used, and thence

Fig. 5.



through the passage *i* and the intercepting-valve to the low-pressure cylinder, and the engine starts with the full power of both cylinders. The steam from the high-pressure cylinder exhausts into the receiver *F F*, fig. 1, and at the proper time passes through the port *k'* and opening *o* and acts on the end of the intercepting-valve. As the area of the pistons *h h'* at that end of this valve exceeds that of the front piston h^2, the pistons are all forced forward, thus opening the ports *j j' k k'* for the passage of the steam from the receiver or connecting-pipe *F* into the low-pressure cylinder, at the same time closing the live-steam ports h^3 in the intercepting-valve, and thus cutting off the live steam from direct action upon the low-pressure cylinder.

The intercepting-valve remains in this position as long as the engine is running and when the throttle-valve is closed. When the engine is again started, the live steam forces the intercepting-valve back, so as to close the connection between the receiver *F F* and low-pressure cylinder, while permitting the live steam to flow directly therein, as hereinbefore explained.

It will thus be seen that under improved organization the passage of live steam to the low-pressure cylinder directly through the intercepting-valve is cut off, and live steam is thus prevented from escaping through the communicating-pipe or receiver to the high-pressure cylinder, which would cause back-pressure, and that when the pressure of the exhaust-steam from the high-pressure cylinder in the communicating-pipe or receiver has risen sufficiently it automatically closes the intercepting-valve, and thus cuts off the live steam from direct access to the low-pressure cylinder, simultaneously opening the port for the passage of the steam from the high to the low-pressure cylinder, all these motions being automatic.

In order to regulate the movements of the intercepting-valve and to prevent any sudden backward and forward action, as would occur were the steam turned on without some compensating device, the piston-rod *H* is prolonged through suitable glands in the valve-chamber *L*, in which a piston *l* slides. Ports *l'* l^2 connect the opposite ends of this chamber, which is filled with oil or some analogous fluid through an opening l^3.

The area of the passage connecting the parts *l'* l^2 may be varied by a transverse screw l^4, fig. 3, so as to control the rapidity of the flow of fluid from one side of the piston to the other, and the consequent rapidity of the movement of the intercepting-valve.

Manufactures.

Bell's Spark Arrester.

THE accompanying illustrations show an improved spark arrester, invented by Mr. J. Snowden Bell, of Pittsburgh, an application for a patent for which is now pending. The object of this invention is to present an area of screen surface sufficient for the effective separation of the solid matters, which may be drawn through the tubes, from the gaseous products of consumption, without impairing the proper draft on the fire or requiring the use of the heavy and costly extended smoke-box.

In the accompanying illustration, fig. 1 shows a longitudinal section of a locomotive smoke-box provided with the improvement, and fig. 2 a cross-section of the same. The construction of the extended smoke-box, with its system of deflectors, is generally understood, and the differences will be readily seen from the engraving and from the description below.

The improvement, as shown, is applied in a locomotive boiler of the ordinary standard construction with tubes 2 2 extending through the shell or barrel 1 1 from the fire-box to the tube-sheet 10, and delivering the products of combustion into the smoke-box 3, which is closed at its forward end by the front 4, having a suitable door, 5, and provided with an open smoke-stack, 11. A deflector or check-plate, 8, secured at the top to the tube-sheet 10, and inclined forward and downward to a proper level is used, but instead of making the same a plain plate it is in this construction, from a level somewhat below the upper row of tubes, grated or perforated with a series of openings of ½ in. or more in diameter, and a supplemental deflector, 9, also inclined downward and forward, is secured to the sheet at or near the line of attachment of the first deflector 8. The openings in this second deflector 9 are smaller in diameter than those in the plate 8, and the upper row of perforations is also at a lower level than the corresponding row in the deflector 8; but if deemed desirable, they may be wholly or partially dispensed with, and the whole or part of the deflector 9 be formed of the plain plate 8. The object of this perforated plate is to disintegrate and extinguish large pieces of unconsumed fuel which may be drawn through the tubes, and thus to prevent the throwing of live coals from the stack.

In connection with these deflectors suitable screens or netting may be used between the exhaust-pipe and the stack. A construction preferred by the inventor is shown in the drawings, and consists of a connected series of inclined transverse screens

FIG. 1

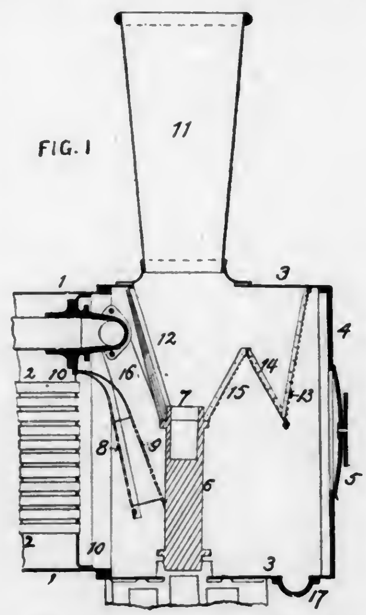
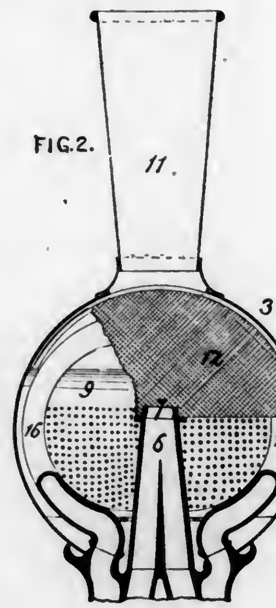


FIG. 2.



or nettings 12, 13, 14, and 15, which may be either of wire netting or perforated metal. The screens 12 and 13 are of segmental form, and 14 and 15 are of zone form, the screen 12 being placed between the steam-pipe 16 and exhaust-pipe 6, in rear of the stack opening, as shown and extending downwardly to the top of the exhaust-pipe, while 13 is placed a short distance from the front ring of the smoke-box inclined backward and extending backward to the same level as 12. The screens 14 and 15 are connected at the top and inclined in A form, 14 being connected at the bottom to 13, and 15 extending to the top and front of the exhaust-pipe. The screens 12 and 15 are separated at the bottom by a space equal to the diameter of the exhaust-

pipe, this space being bridged on each side of the exhaust-pipe by a suitable connecting piece, which may be either perforated or plain. The outer surfaces of all the screen sections conform to the curvature of the smoke-box, and are connected thereto by angle irons in the usual manner, as shown in the drawings. While the segmental screen shown as a partition in rear of the exhaust-pipe is preferred, it is not essential to the improvement, and any other suitable partition, either perforated or plain, may be substituted for it.

The smoke-box projects in front of the cylinder saddle only enough to permit of the attachment of the cinder discharge 17. This may be simply a hole with a suitable cap or cover, or where the fuel used is such as to render a spark receptacle desirable, a separate chamber may be connected without any change in the other arrangements.

It will be seen that by this construction a material increase of screen area is attained without increasing the length of the smoke-box, and there being no horizontal portion except the narrow connecting piece uniting the screens 12 and 15 at the bottom, nearly all of this area is presented in an inclined position, which, it is claimed, more effectually resists the tendency of solid matter to pass through the screens, and renders a larger mesh or perforations admissible. In this way the advantages claimed for the extended smoke-box are secured without the accompanying drawbacks.

Anthracite Coal Production.

THE official report of the production of anthracite coal for the year ending December 31, is as follows :

	1889.		1888.	
	Tons.	Per ct.	Tons.	Per ct.
Wyoming Region	18,647,925	52.7	21,852,366	57.3
Lehigh Region	6,285,421	17.7	5,639,236	14.8
Schuylkill Region	10,474,364	29.6	10,654,116	27.9
Total	35,407,710	100.0	38,145,718	100.0

The decrease last year from 1888 was 2,738,007 tons, or 7.2 per cent. In addition the stock of coal on hand at tidewater points—1,026,107 tons on December 31 last—showed an increase of 373,951 tons.

Eastern competitive tonnage—which includes all anthracite coal which, for final consumption or in transit, reaches any point on the Hudson River or the Bay of New York, or which passes out of the Capes of the Delaware—was 12,217,862 tons last year ; a decrease of 1,439,742 tons, or 10.5 per cent., from the previous year.

Locomotives.

THE Brooks Locomotive Works, Dunkirk, N. Y., have an order for 10 heavy passenger engines for the Wisconsin Central Railroad.

THE Rogers Locomotive Works, Paterson, N. J., recently delivered two passenger and 10 mogul freight engines to the Georgia Pacific Railroad. The same works have an order for 10 consolidation freight engines and 10 heavy switching engines for the Louisville & Nashville Railroad.

THE Dickson Manufacturing Company, Scranton, Pa., has an order for 25 locomotives for the New York, Ontario & Western Railroad branch to Scranton.

THE Schenectady Locomotive Works, Schenectady, N. Y. recently delivered a passenger engine with 17 × 24 in. cylinders, and a 12-wheel freight engine with 20 × 26 in. cylinders to the Beech Creek Railroad.

THE Baldwin Locomotive Works are building a considerable number of locomotives for export. Many of these must be made in conformity with the specifications of English and European engineers, and in several cases the use of wrought-iron spoke-wheels for truck, driving, and tender-wheels has been insisted upon. The present condition of affairs in Europe is such that it is difficult to obtain railroad equipment or material of any character for reasonably early delivery. The Baldwin Works were therefore compelled either to decline orders offered or to find some means of furnishing wrought-iron wheels themselves. They have therefore undertaken to make these wheels so far as forced to by the requirements of the locomotive business. In doing this a system of manufacture was adopted which is novel, and is believed to have greater merit than any other now in use. There is no intention, however, of making wrought-iron wheels for any other purpose than that indicated above.

Iron Production.

THE American Iron & Steel Association reports that the production of pig iron in the United States for three years past has been, in net tons :

Fuel.	1889.	1888.	1887.
Bituminous	5,952,414	4,743,989	4,270,365
Anthracite and coke	1,575,996	1,648,214	1,919,640
Anthracite alone	344,358	277,515	418,749
Charcoal	644,300	598,789	578,182
Total	8,517,068	7,268,507	7,186,936

In addition to the increase in output there is reported a decrease in stocks on hand unsold of 58,760 tons, which should be added to the gain of 1,248,561 tons in production.

The chief increase in consumption was in Bessemer pig iron, showing once more a point heretofore referred to, the increasing use of steel in manufactures and construction.

The increase was pretty well distributed over the iron-producing States. The relative gain, however, was largest in the South, the figures for the Southern States being : 1,566,702 tons in 1889 ; 1,132,858 tons in 1888 ; 929,436 tons in 1887. In Alabama alone the pig iron output increased from 292,762 tons in 1887 to 791,425 tons in 1889 ; Tennessee, Virginia, and West Virginia also show large gains.

The production of last year was pretty well distributed through the year. It was the largest ever reported for this country for a single year.

Bridges.

THE contract for the Newtown Creek draw-bridge for the city of Brooklyn has been let to Dean & Westbrook. It is an 80-ft. counterbalanced draw-span.

THE Pencoyd bridge shops have been shipping material for the Union Elevated Railroad of Brooklyn, at the rate of 200 tons a day.

THE Rochester Bridge Works have the contract for a 120-ft. pony truss for the Kansas City, Fort Scott & Memphis Railroad. The Buffalo shops of the Union Bridge Company are building for the same road a 65-ft. and an 80-ft. steel plate girder bridge.

THE New York, Lake Erie & Western Railroad has made a permanent contract with the Union Bridge Company to build all its bridges. Considerable work is now in the shops at Athens.

THE Paterson Rolling Mill Company has the contract for a 150-ft. span, and several girder spans for the Chesapeake & Ohio Railroad. This Company is also building the extension of the Hudson County Elevated Railroad in Jersey City.

THE new shops of the Elmira Bridge Company are hardly yet in running order, though most of the machinery is in position and ready for work. The principal trouble is lack of material, which is also giving the Union shops much trouble. They are working on three contracts—viz., the Schuykill Viaduct, 1,200 ft. long, for the Schuykill & Lehigh Valley Railroad, a feeder of the Lehigh Valley ; an 80-ft. plate girder span for the Lehigh Valley Railroad, and a 150-ft. double-track plate girder draw span for the New York Central Railroad.

OBITUARY.

WILLIAM H. TURNER died at his residence in New Rochelle, N. Y., January 31, aged 54 years. Mr. Turner was an old railroad man, having entered the office of the Norwich & Worcester Railroad when only 17 years old ; after having served on that road as clerk and freight agent, he was for a time Superintendent of the Portland & Rochester Railroad, and later of the Boston & New York Air Line. More recently he was Superintendent of the Eastern Division of the New York & New England, and afterward General Superintendent of that road ; for three years past he has been Superintendent of the New York Division of the New York, New Haven & Hartford Railroad.

DANIEL ADAMSON, who died in Manchester, England, January 13, was well known as one of the largest manufacturers of boilers and machinery in England. He was born in 1820, and

learned his trade under Mr. Hackworth in the Stockton & Darlington Railway shops. He was inclined to introduce new methods and make innovations to an extent somewhat unusual in England, and invented and patented a number of machine tools. He was one of the first projectors of the Manchester Ship Canal, and was mainly instrumental in the formation of a company for that enterprise.

WILLIAM JARVIS MCALPINE, who died at his residence at New Brighton, N. Y., February 16, aged 78 years, was one of the oldest and best known of American engineers. He was born in New York City, and when 15 years old began work in an engineer corps, learning his profession chiefly in the field and on canal work. His first prominent position was as Engineer in charge of the enlargement of the Eastern Division of the Erie Canal. In 1846 he was made Chief Engineer in charge of the building of the dry-docks at the Brooklyn Navy Yard, and was employed there for several years. In 1852 he was elected State Engineer of New York, and held office four years. Later he was Chief Engineer of the Erie Railroad for some time, and was also on several other prominent roads.

Among important works which Mr. McAlpine planned were the water-works of Chicago, Albany, and several other cities; several river improvements in this country, and the plans for the improvement of the Danube for the Austrian Government. For several years past he has retired from active work, but has been much employed as a consulting engineer on many important works, among them the State Capitol at Albany.

Mr. McAlpine had been for many years a member of the American Society of Civil Engineers; he was President of the Society in 1868–69, and was made an Honorary Member in 1888. To the last he took an active interest in his profession.

PERSONALS.

J. T. HARAHAN has resigned his position as General Manager of the Chesapeake & Ohio Railroad, which he has held since March last.

COLONEL J. W. ROBERTSON has been appointed a member of the Georgia Railroad Commission in place of Major Campbell Wallace, who has resigned.

G. T. JARVIS has been appointed Division Superintendent of the Baltimore & Ohio Railroad, with office at Newark, O., succeeding R. T. DEVRIES, who has resigned.

FREDERICK A. SCHEFFLER, recently Superintendent of the Erie City Iron Works, Erie, Pa., is now Acting General Superintendent of the Westinghouse Electric Company in Pittsburgh.

E. D. BRONNER has been appointed Master Car-Builder of the Michigan Central Railroad, succeeding Mr. ROBERT MILLER. Mr. Miller still remains Assistant General Superintendent of the road.

H. TANDY has resigned his office as Superintendent of Motive Power of the New York, Ontario & Western Railroad, to accept the position of Superintendent of the Brooks Locomotive Works at Dunkirk, N. Y.

COMMANDER WILLIAM M. FOLGER, U. S. N., has been appointed Chief of the Bureau of Ordnance in the Navy Department, with the rank of Commodore. This appointment has been expected for some time.

HARRY MONKHOUSE has been appointed General Master Mechanic and Assistant General Master Car-Builder of the Chicago, Rock Island & Pacific Lines west of the Missouri River. His office is at Horton, Kan.

COLONEL C. W. RAYMOND, U. S. Engineers, has been relieved from duty as Engineer Commissioner of the District of Columbia, and will be assigned to other duty. He is succeeded by LIEUTENANT-COLONEL J. M. ROBERT, U. S. Engineers.

J. S. PATTERSON is appointed Master Mechanic of the Columbus, Hocking Valley & Toledo Railroad, and will have charge both of the motive power and car departments. He succeeds Mr. I. G. HUTCHINS, Master Mechanic, and J. M. ROCKAFIELD, Master Car-Builder, who have resigned.

GEORGE F. WILSON is appointed General Master Mechanic of the Chicago, Rock Island & Pacific Railway, and his jurisdiction will extend from the Company's lines both east and west of the Missouri River, with headquarters in Chicago. He succeeds Mr. T. B. TWOMBLY, who has resigned after many years' service on the road.

MAJOR CAMPBELL WALLACE has resigned his position on the Georgia Railroad Commission. He has been a member of the Commission since its first organization, and has taken a very active share in its work. Major Wallace is a practical railroad man of long experience, and has been a very useful officer. He is now 86 years old, and retires from active work altogether.

H. WALTER WEBB has been appointed Third Vice-President of the New York Central & Hudson River Railroad; this is a new office, and the holder will have general supervision of the Operating Department. Mr. Webb has been for some time Assistant to the President and also President of the Wagner Palace Car Company. At the same time General Superintendent JOHN M. TOUCEY was appointed General Manager, and Assistant General Superintendent Theodore Voorhees was made General Superintendent of the road.

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers.—At the regular meeting, February 5, a paper was read by Mr. Cope Whitehouse on the Raiyan Canal and Storage Reservoir, Egypt.

The tellers announced elections as follows: *Fellow of the Society.*—V. M. Clement, of Idaho.

Members.—Oscar F. Balston, Brooklyn, N. Y.; George Codwise Dickinson, Fort Montgomery, N. Y.; Joseph Hobson, Hamilton, Can.; John Alexander McDonald, Sidney, N. S. W., Australia; Maurice Stiles Parker, Winona, Minn.; Edward Clapp Shankland, Pittsburgh, Pa.; William Henry Warren, Sidney, N. S. W., Australia; George Leverett Wilson, St. Paul, Minn.

Juniors.—Edward Hanson Connor, Buffalo, N. Y.; Amory Prescott Folwell, Glenns Falls, N. Y.; Edward Etienne de Lancey, Sing Sing, N. Y.; Hugo S. Speidel, Paterson, N. J.; John Frederick Temple, Edge Moor, Del.; Henry Grattan Tyrrell, Pencoyd, Pa.; Thomas Tainter Watson, Morristown, N. J.

American Geological Society.—The annual meeting of this Society was held in New York, beginning December 27 and ending December 29. There was a large attendance at the opening meeting, and after the usual preliminary addresses the reports of the Treasurer and Secretary were read and approved. The following officers were elected for the ensuing year: President, James D. Dana; Vice-Presidents, John S. Newberry and Alexander Winchell; Secretary, John J. Stevenson; Treasurer, Henry S. Williams; Executive Council, J. W. Powell, George M. Dawson, and Charles H. Hitchcock.

It was announced that 15 new Fellows had been elected. Announcement and comment was made on the deaths for the past year, which included Professor George H. Cook, David Honeyman, and Dr. C. A. Ashburner.

The remaining sessions were devoted entirely to the reading of papers, many of which were of an entirely technical character. Among those presenting papers were Professors T. H. Chamberlin, N. S. Shaler, Robert Bell, S. F. Emmons, George H. Williams, Charles D. Walcott, and others. Many of these papers called out considerable discussion from members present.

The Society was reported to be in a very flourishing condition, and much good work has been accomplished during the past year.

American Geographical Society.—At the annual meeting in New York, January 14, the following officers were elected: President, Charles P. Daly; Vice-President, Francis A. Stout; Secretary, James M. Bailey; Treasurer, Walter R. T. Jones; Councillors, William Remsen, John A. Hedden, Clarence King, Christian Börs, and Edward King.

The President then delivered his annual address, which was chiefly a review of the discoveries by excavations in Eastern countries of recent years and their relation to the history of man.

Master Mechanics' Association.—A number of circulars of inquiry have recently been sent out from the office of the Secretary, Mr. Angus Sinclair.

The Committee on Axles for Heavy Tenders asked for opinions on the best dimensions and form of such an axle, and on the limit of weight on journals per square inch of contact. The Chairman of this Committee is William Swanston, Master Mechanic of the Chicago, St. Louis & Pittsburgh Railroad, Indianapolis, Ind.

The Committee on the Advantages and Disadvantages of Placing the Fire-Box above the Frames request opinions and

experience on this subject; also information as to the form and depth of fire-box preferred, and as to any experience gained with either form. The Chairman of this Committee is Mr. F. B. Griffith, Master Mechanic of the Delaware, Lackawanna & Western Railroad of Buffalo, N. Y.

The Committee on Corrosion of Water Tanks request information on this subject, and also as to devices which may have been adopted to prevent it. The Chairman is Mr. W. J. Robertson, Superintendent of Motive Power of the Central Vermont Railroad, St. Albans, Vt.

The Committee on the Relative Value of Steel and Iron Axles request opinions as to the safe limit of diameter for driving-axles, truck-axles, and tender-axles for different weights on journals; also information as to the relative wear of steel and iron axle journals and bearings per 50,000 miles run, and as to endurance and comparative number of breakages of axles. The Chairman is Mr. John McKenzie, Superintendent Motive Power of the New York, Chicago & St. Louis Railroad, Cleveland, O.

The Committee on Efficiency of the Link Motion, as compared with other valve motions, asked for any information attainable on this subject, including results of tests, indicator diagrams, first cost and maintenance, etc. The Chairman is Mr. James M. Boone, Superintendent Motive Power, West Shore Railroad, Frankfort, N. Y.

The Secretary has also issued a circular urging upon members the necessity of answering questions as fully and as promptly as possible, in order to enable the Committees to do satisfactory work.

Master Car-Builders' Association.—The Executive Committee issued the following circular under date of December 24, 1889:

"Under the duties imposed upon the Executive Committee by By-Law No. 3, this Committee announces that it has selected Old Point Comfort, Va., as the place for holding the next Annual Convention of the Master Car-Builders' Association, commencing on Tuesday, June 10, 1890. The headquarters of the Association will be at the Hygeia Hotel, the management of which has named a uniform rate of $3 per day for all who attend the Convention. The Committee of Arrangements consists of Messrs. Wade, Day, and Demarest, but members who wish to engage rooms in advance should address Mr. F. N. Pike, Manager Hygeia Hotel, Fortress Monroe, Va.

"The Executive Committee regrets that Charleston, S. C., the place selected at the last Convention, is ineligible on account of insufficient hotel accommodations for a fairly well-attended Convention of the Association, because the Committee realizes that the well-known hospitality of Charleston would have insured a pleasant reception to the Association.

"The Committee also found Look-Out Mountain, near Chattanooga, Tenn., ineligible for the same reason; when the new hotel, now being built at this point, is completed, it will probably be capable of accommodating the Association, and although the management promises to have it opened in May, the Executive Committee thought it best to select a place where the necessary accommodations already exist.

"Buffalo, N. Y., was mentioned as one of the three places for the Executive Committee to consider, but the subsequent action of the Convention, restricting its choice to Charleston, and the manifest desire on the part of many members to go South in 1890, have led the Committee to disregard Buffalo, believing that by the selection as above announced it meets the wishes of a larger portion of the membership than could be done by the selection of any other place."

Canadian Society of Civil Engineers.—The fourth annual meeting was held in Montreal, January 23. The annual report showed that there are now 70 members of the Society. The President delivered his annual address, which related principally to the progress of engineering in Canada, and incidentally gave some account of the principal works now in progress. The Governor-General then made a short address.

The following officers were elected for the ensuing year: President, Colonel C. S. Gzowski; Vice-Presidents, John Kennedy and E. T. Hannaford; Treasurer, H. Wallis; Secretary, H. T. Bovey; Librarian, C. Chadwick.

Boston Society of Civil Engineers.—At the regular meeting in Boston, January 15, Louis M. Bancroft and George M. Fernald were elected members. The new Constitution and By-laws reported at a former meeting were adopted. They contained provisions for a new class of members called Associates, to which persons who are not engineers by profession are eligible. It also provides for temporary membership of persons who are members of other engineering societies, but residing for a limited time in or near Boston.

The Secretary and Treasurer were appointed a Committee to arrange for the annual dinner on March 12. It was resolved to employ a stenographer to report the discussions at the meetings.

Professor Thomas M. Drown read a paper on the Filtration of Natural Waters, which was discussed by Dr. Samuel W. Abbott, of the State Board of Health, and by Messrs. FitzGerald, Smith, and Watson, members of the Society.

New England Railroad Club.—At the regular meeting in Boston, February 12, the subject for discussion was the form of Contract for Chilled Wheels adopted by the Master Car-Builders' Association. It was opened by Mr. J. N. Lauder, who read a paper by Mr. W. W. Snow. The discussion was carried on by Messrs. Marden, Shinn, Curtis, Adams, and Nye, and developed great difference of opinion, the wheel-makers claiming that the contract did not do them justice.

Engineers' Club of Philadelphia.—At the regular meeting, January 18, the Secretary presented for Mr. Charles S. Churchill an illustrated paper on an Economical Form and Construction of Arches in Railroad Embankments. The paper was based on investigations made and plans and facts collected some time ago, when the Author made a number of experiments on the pressure of earth to be resisted by such arches both of small or larger spans. There was considerable discussion of this paper and on arches in general.

Engineers' Society of Western Pennsylvania.—At the regular meeting in Pittsburgh, December 17, C. I. McDonald and J. R. Reed were chosen members.

Mr. Alfred E. Hunt read an elaborate paper on Stone Used for Structural Purposes in Alleghany County, giving the results obtained with a number of different stones, the sources from which they were brought, and other particulars. This was discussed by Messrs. Becker, Hoag, Schneider, Scaife, and Brashear, many interesting facts being brought out in the discussion.

Central Railroad Club.—The annual meeting was held in Buffalo, N. Y., January 22, with a large attendance. Five new members were elected. Reports were presented on Seam-checks in Car-wheels and on Evaporation in Locomotives Burning Bituminous Coal. Both of these reports were discussed.

The Committee on the Interchange Rules presented a report recommending several changes. This was discussed for some time, and the Committee was continued with the addition of four members to its number.

Officers were elected for the ensuing year as follows: President, Eugene Chamberlain; Vice-President, A. C. Robinson; Secretary and Treasurer, F. B. Griffith; Executive Committee, T. A. Bissell, J. D. McIlwain, P. H. Griffin, C. A. Gould, Peter Smith, James Macbeth and C. E. Rood.

After the conclusion of the meeting the annual dinner was held, at which there were present 80 members and invited guests, and which was much enjoyed by those present.

Engineering Association of the Southwest.—At the regular meeting in Nashville, Tenn., January 9, communications were received from the Association of Engineering Societies relative to the subject of the formation of a national organization of engineering societies, and from President MacLeod, of Louisville, Ky., donating a pair of large photographs of the recently constructed Kentucky and Indiana bridge over the Ohio River at Louisville. The photographs were taken in April, 1886, during a 55-ft. rise of the Ohio River, and showed the cantilever trusses in process of erection, and presented ocular proof of the superiority of the cantilever type of bridge in the important particular among others of requiring for erection no false-work that might be endangered by unexpected floods in the river, which caused one of the long spans of the Chesapeake & Ohio bridge at Cincinnati to fall while resting on the false-work during the summer of 1888. The photographs are the first of a collection of maps, drawings, photographs, plates, models, and specimens which it is one of the expressed objects of the Association to gather and preserve in its permanent quarters.

Reports were read from the standing Committee on Rooms and Library relative to the furnishing of the recently selected quarters in Baxter Court, and from the standing Committee on Papers and Printing, relative to the system of receiving and presenting papers at the regular meetings. Suitable papers, discussions of papers, notes of professional experience, and items or accounts of technical interest are solicited from the membership, and such matter on any subject will be received

and presented at any time, though it is requested that, as far as is practicable, such matter shall be submitted in conformity with a prearranged schedule of general topics, by which each regular meeting for several months in advance shall have assigned to it a particular though comprehensive topic, under which all papers or communications on any particular subject closely allied to the general topic shall be admitted.

The constitution of the Association provides that one of the means by which its objects are to be obtained may be the taking of organized action on matters pertaining to engineering and allied professions. Acting under this provision the following resolutions, bearing on the subject of highway reform, were introduced:

"*Whereas*, The subject of efficient highways is one of the highest importance to the social and material welfare of the public; and

"*Whereas*, The questions involved in the bringing of highway systems to a high state of efficiency are largely questions falling within the province of engineers to consider; therefore, be it

"*Resolved*, That this Association express its appreciation of the desirability and the urgent necessity for strong and effective measures on the part of county and State legislatures looking to the improvement of public highway systems.

"*Resolved*, That a special committee of five members of this Association be appointed by the President, whose duty it shall be to consider and report at an early meeting what steps, in its opinion, the Association may properly take in order most effectively to aid in the general work of highway improvement."

The resolutions were referred to the Board of Directors for submission to the membership by letter-ballot.

The paper of the evening on a Chemical Examination of the Water Supply of Natchez, Miss., was then read by Dr. William L. Dudley, of Vanderbilt University. The paper comprised primarily a comparison of chemical analyses of water submitted from two possible sources of supply for the city of Natchez, namely, the Mississippi River opposite that city, and deep bored wells sunk between the Natchez bluffs and the river; though, as treated by the Author, the paper was given a much wider scope by his clear and concise presentation of the relation which a chemical analysis bears to a proper knowledge of the potability of a water supply; a question of great importance to sanitary engineers. The analysis showed the superiority of the well-water over the river water in having less solids in suspension, less organic matter, in solution, less albuminoid ammonia, and a lesser degree of permanent hardness; but inferiority to the river water in having nearly three times as high a degree of temporary hardness, and a small excess of total hardness.

The Association will begin at an early date the publication and distribution among its membership of the more valuable papers read at the meetings.

Engineers' Club of Cincinnati.—At the regular meeting, January 16, Alfred Bull and A. S. Hobby, Jr., were chosen members Mr. L. W. Mathewson read a very interesting paper on Street Construction, which included a description of the construction of various kinds of street pavements and of the material used in them. This paper was followed by an interesting discussion in which Messrs. Merrill, Hobby, Carlisle, Hilgard, Burke, Nicholson and Wallace took part.

Western Society of Engineers.—At the regular meeting in Chicago, February 5, President Cooley made an address outlining the policy of the Society for the ensuing year.

Mr. O. Chanute gave an account of the Paris Exposition as seen by him, and showed what was to be done in preparing for the Exposition of 1892, in the light of the experience had in Paris.

Western Railway Club.—At the regular meeting in Chicago, February 18, a paper on Steel Plate and Malleable Iron in Car Construction was read by Mr. E. W. M. Hughes, and discussed.

There were short discussions on Valve Motions and on Car Roofs. The Rules of Interchange of the Car-Builders' Association were also suggested for discussion.

Northwestern Track & Bridge Association.—At the regular meeting in St. Paul, February 15, there was a discussion of the paper on Track Shimming read by Mr. Kimball at the previous meeting.

Mr. John Copeland read a paper on Care of Pile Bridges in Winter, which was briefly discussed.

This Association has been organized at St. Paul, Minn., with the following officers: President, John McMillan; Vice-Presidents, W. S. Darby and George W. Kimball; Secretary, D. W. Meeker; Treasurer, John Copeland.

At the first regular meeting a paper on Track Shimming was read by Mr. G. W. Kimball. Discussion was postponed till the next meeting.

Northwest Railroad Club.—At the regular February meeting Mr. W. H. Lewis read a paper on Axles for Heavy Tenders, in which he recommended the use of an axle with journals 4 in. diameter and 8 in. long, the axle to be not less than 5⅝ in. diameter at the wheel-seat and 4⅝ in. at the center. This was discussed by Messrs. McIntosh, Greatsinger, Whitaker, Pattee, and Warren, most of them favoring a smaller journal.

Engineers' Club of St. Louis.—At the regular meeting January 22, B. J. Arnold and James Dun were chosen members. The Committee on the Eads Monument reported progress.

Professor W. B. Potter then read a paper on Fuel Gas, considering the subject under the heads of Natural and Manufactured Gas. He assumed the amount of natural gas now consumed is equivalent to about 15,000,000 tons of coal yearly. He believed that under present conditions manufactured fuel gas could not be profitably used in steam boilers, but believed that the cost of manufacture and the price of manufactured gas would be so reduced that it could be largely used for domestic purposes.

Mr. E. McMillin made an address on the same subject, agreeing generally with Professor Potter's statements. The subject was further discussed by a number of members present.

At the regular meeting, February 5, J. L. Ayers, C. W. Counet, B. L. Crosby, J. H. Curtis, G. H. French and A. Winslow were chosen members.

Mr. George D. Dudley read a paper on Tests of Water Works Engines, explaining the precautions necessary to be taken in making such tests in order to secure results of value. He also submitted reports on two tests of engines. This was discussed at considerable length by a number of the members present.

The Secretary then read a paper by Mr. J. H. Kinneally, entitled Some Mathematics on Ventilation. This was also discussed by members present.

Engineers' Club of Kansas City.—At the regular meeting held January 6, the reports of the Executive Committee and the Treasurer were presented. Messrs. O. B. Gunn and W. B. Knight were appointed to serve on the Committee on National Public Works and Messrs. Kiersted and Henry Goldmark on the Committee on Affiliation of Engineering Societies.

The tellers announced the election of the following officers for the ensuing year: President, W. H. Breithaupt; Vice-Presidents, J. A. L. Waddell and A. J. Mason; Secretary, Kenneth Allen; Treasurer, F. W. Tuttle; Librarian, C. E. Taylor; Directors, W. B. Knight and W. Kiersted.

The retiring President, Mr. O. B. Gunn, then delivered an address referring to the prosperous condition of the Club, the work done by various members and several of the great engineering enterprises now being carried out.

Denver Society of Civil Engineers & Architects.—At the regular meeting in Denver, Col., January 28th, the following officers were elected for the ensuing year: President, George G. Anderson; Vice-Presidents, L. Aulls and C. P. Martin; Secretary and Treasurer, George H. Angell; Executive Committee, P. H. Van Diest, R. D. Hobart and F. E. Edbrooke.

A Committee was appointed to consider all matters appertaining to a national association and to union with other Societies. Messrs. C. P. Allen, William H. Weller and Ernest Van Dreveldt were elected members.

Mr. R. A. Wilson then read a paper upon the Necessity of Good Triangulation Surveys, speaking also of the importance of good topographical maps of the State.

Montana Society of Civil Engineers.—The annual meeting was held in Helena, Mont., January 18. The Secretary reported that there were now 56 active and two associate members. The Treasurer reported expenditures amounting to $287 and a balance of $184 on hand. Mr. Sizer was appointed to fill a vacancy in the Committee on National Public Works.

The election of officers for the ensuing year was announced as follows: President, Eldridge H. Beckler; Vice-Presidents, John Gillie and John Herron; Secretary and Librarian, Charles E. Griffith; Treasurer, Albert S. Hovey; Trustee, A. E. Cumming. The new President made a short address and votes of thanks were passed to the retiring officers.

Technical Society of the Pacific Coast.—At the annual meeting in San Francisco, January 24, the following officers were elected: President, John Richards; Vice-President, Professor F. Soule; Treasurer, James Spiers: Secretary, Otto von Geldern; Directors, Ross E. Browne, L. L. Robinson, Herman Kower, S. H. Smith and Hubert Visscher.

Tacoma Society of Civil Engineers and Architects.—At the regular meeting in Tacoma, Wash., December 20, a discussion took place on Piles, in which the many experiments made by the Northern Pacific in the Puget Sound country were given by its Engineer, H. S. Huson, and discussed by members present. In that country the destruction of piles by boring animals is very rapid, and timber being very cheap, it has heretofore been less costly to renew them than to protect them. Attention has been called to the use of concrete and of Ventura asphalt.

A paper was read by S. A. Cook on Construction of Buildings, and another one on the same subject by James Morrison. Both referred to the necessity of better building and better sanitary arrangements.

At the annual meeting, January 17, the following officers were elected: President, D. D. Clarke; Vice-President, Arthur L. Smith; Secretary, William G. Gosslin; Treasurer and Librarian, F. G. Blake. The officers reported the Society in a flourishing condition, and that suitable rooms had been procured.

William J. Wood read a paper upon the Coal Deposits of the State of Washington, their nature and probable area, which was of much interest.

C. O. Bean read a paper upon Street Improvements, which was generally discussed, and which condemned wooden pavements, which are largely used at present in that country of cheap timber.

Connecticut Association of Civil Engineers & Surveyors.—At the annual meeting in Hartford, January 14, the Secretary's report showed a membership of 80, and several new members were admitted. President C. H. Bunce made a carefully-prepared address, showing what engineering work had been done in the State during the year, and calling attention to the necessity of having town lines fixed and marked. Messrs. Weld, Whitlock, and Hull were appointed a committee to attend the next annual State convention of selectmen and urge action in regard to the boundaries.

In the afternoon A. R. Wadsworth, of Farmington, read a paper on the Farmington Water-Works, and F. Floyd Weld, of Waterbury, read an article entitled Notes on the Care of Sewers. W. E. Petter, of Lakeville, spoke of the methods of heating passenger cars. The Committees on Railroads, Sewers, Masonry, Roads and Road-Making, and Water-Works made reports.

Officers were elected as follows: President, F. Floyd Weld, of Waterbury; Vice-Presidents, William B. Palmer, of Bridgeport, and E. P. Augur, of Middletown; Secretary and Treasurer, F. W. Whitlock, of Waterbury; Assistant Secretary, W. H. Burnett, of Norwich; Executive Committee, F. F. Weld, C. H. Bunce, C. M. Jarvis, C. E. Chanler, and B. H. Hull; Membership Committee, T. H. McKinney, E. P. Augur, and W. B. Palmer.

Ohio Society of Surveyors & Engineers.—At the annual meeting in Columbus, O., January 21–23, among the papers read were the following: The Motor in Engineering, by B. F. Thomas; County Surveyors, by William Peters; Sewage Disposal, by Doctor Edward Orton; Town and Village Water Works, by G. B. Strawn; Rural Water Supply, by J. Arenett; Natural Gas, by H. L. Webber. There were also papers read and discussed on Street Construction, on Highways and on Railroad Permanent Way.

Officers were elected as follows: President, J. F. Buck, Cardington; Vice-President, G. R. C. Brown, Ironton; Secretary and Treasurer, Julian Griggs, Columbus.

Indiana Society of Civil Engineers & Surveyors.—At the annual meeting in Indianapolis in January, the usual business was transacted, and the following officers were elected: President, P. I. Morris, Knightstown; Vice-President, L. S. Alter, Remington; Recording Secretary, J. R. Brown, Frankfort; Corresponding Secretary, G. M. Cheney, Logansport; Treasurer, H. P. Faitout, Indianapolis; Executive Committee, Jacob Norris, W. A. Osmer, R. H. Wallace, R. J. Morrison and G. M. Cheney.

Illinois Society of Engineers & Surveyors.—The fifth annual meeting was held in Peoria, Ill., January 29, continuing for three days. The meeting included several excursions to the water-works and manufacturing establishments in and near Peoria and over the electric railroad. A large number of drawings and photographs of structures and machinery were exhibited by members.

The following officers were elected for the ensuing year: President, A. N. Talbot, Champaign; Executive Secretary and Treasurer, S. A. Bullard, Springfield; Recording Secretary, S. F. Balcom, Champaign.

Among the papers presented were the following: Sharp Curves, by Edwin H. Hill; The Use of Mortar, by Professor I. O. Baker; The Cairo Bridge, by S. F. Balcom; Washington Street Tunnel, Chicago, by S. C. Colton; Iron Highway Bridges, by J. H. Burnham; Peoria Water Works, by W. C. Hawley; Preventing Abrasion of River-Banks, by E. J. Chamberlain; The Engineer and his Work, by C. G. Elliott. There were also discussions on Repairs of Pile Bridges, Ties and State Jurisdiction as to railroad accident.

Michigan Engineering Society.—The Eleventh Annual Convention of this Society was held in Detroit, Mich., beginning on Tuesday, January 21. The programme for the meeting was as follows:

January 21: Papers on Engineering, by H. C. Thompson; Long and Short Haul in Earth Work, by O. C. Gillette; The Mexican Boundary Survey, by J. H. Forster; The Northern Boundary Survey, by Professor C. E. Denison.

January 22: Papers on the Plane Table, by Professor H. B. Davis; Bridge Inspection, B. Douglass; the St. Clair Tunnel, A. L. Reed; Photographic Surveying, Professor R. C. Carpenter; Harbor Point Resort, George E. Steele; Surveying in Oklahoma, O. H. Todd. The evening was devoted to a social meeting and reception.

January 23: Papers on Irrigation, by Professor L. G. Carpenter; Drainage of the Huron Peninsula, F. F. Rogers; Laws on Drainage, Willis Baldwin; Means Employed in Running a Straight Line, George L. Wells; Paper, Professor M. E. Cooley; Ypsilanti Water-Supply, W. R. Coats.

The business session for election of officers, etc., was held January 23. In addition to the reading of papers, opportunity was given at several sessions for miscellaneous debate, asking of questions, etc.

NOTES AND NEWS.

An Air Ship.—The following will thrill the soul of every boy who reads it: "A kite 16½ ft. high and 12 ft. wide, made of 54 yards of linen, was recently made by five boys in Terryville, Conn. At its first ascent it went up 2,000 ft."

A Great Freight Yard.—The Baltimore & Ohio's new yard at Berlin, Md., will be about two miles long by about 500 ft. wide. The main tracks will spread at either end and bind upon each side of the yard. The main sidings, one on each side of the yard, will be immediately inside of and parallel with the main passing tracks. Inside of and parallel with the main sidings are the bases of the diagonal, from and between which are laid the diagonal tracks running at an angle of about 30°. Of these diagonals there are to be 70, each with a capacity of 45 cars, on the basis of 37 ft. space for each car, measuring from bumper to bumper. This gives the yard an aggregate capacity inside of the base of 3,150 cars. Each diagonal will connect with the base on either side by easy switches. The bases will connect with the main sidings at intervals of 10 diagonals, but such connections may be increased to any number desired. The main tracks will have only two connections with the yard, one at each end, so that passenger trains may not suffer the slightest delay. The diagonal tracks are to be numbered from 1 to 70.

Each diagonal will be reserved for its own particular train. For instance, Nos. 1, 2, 3, and 4 may contain all cars intended for Locust Point, and none other; Nos. 5 and 6 only those for Camden Station; Nos. 7, 8, and 9 for Philadelphia, 10 and 11 for New York, 12 and 13 for the Valley, 14 for the Hagerstown

Branch, 15 and 16 for Washington, 17, 18, 19, and 20 for Pittsburgh Division, 21 to 30 for the Baltimore & Ohio Southwestern, etc. So that in ordering out an engine and crew for a Locust Point run, say, the yardmaster simply directs: "Find your train of 25 cars (or 30 or 45 cars, as the case may be) on No. 2." By the peculiar construction of this yard there is no danger, it is claimed, of blocking it. Thirty to 40 switching engines can work in the yard at the same time without interfering with one another. Incoming freight trains will pull into the main siding from the main track at the end of the yard, and from the main siding to the base, where it is left to the switch engine, the main-line locomotive and crew proceeding to the round-house.

The round-houses, warehouses, etc., are to be at the west end of the yard. The entire yard will at night be bright as day with the use of arc electric lights.

It is probable that the officials will in the near future increase the length of freight trains to 45 cars. Twenty-eight is the usual number hauled by one locomotive at present.—*Baltimore Sun.*

A Great Light-House.—The Light-House Board expects to open bids next July for the erection of a light-house on the Outer Diamond Shoal off Cape Hatteras, which will be one of the notable light-houses in the world, on account of the difficulties in the way of its construction which have hitherto prevented the erection of any light-house there. The Light-House Board does not specify the method to be adopted by the builders, but it is generally understood that the design is for an immense caisson, 80 or 100 ft. in diameter, which will be towed out to the shoal and sunk in place as rapidly as possible. The sand will be excavated from the caisson and it will be sunk until its edges rest upon the bed-rock, when it will be filled with concrete to a height some 30 ft. above high water, and a light-house tower which will be 150 ft. in height will be founded upon this mass. The caisson will be protected outside by a riprap of heavy granite blocks. The tower itself will be of steel. The placing of the caisson and the construction of the foundation will be exceedingly difficult on account of the constant interruptions which may be expected from rough weather, as the sea off Cape Hatteras is seldom long at rest.

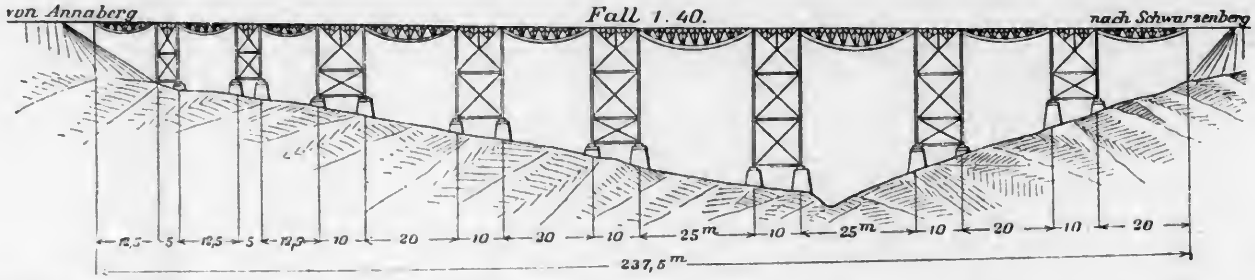
Young Men's Christian Association.—We learn from the *Rocky Mountain Messenger*, published by the Railroad Department of the Young Men's Christian Association on the Union Pacific Railroad, that that organization now has rooms on the line of the road at Rawlins, Wyo.; Pocatello, Ida., and Ogden, Utah, the work at each place being in charge of a local secretary. At each of these points the rooms, which are provided with baths, library and other conveniences, are very attractive, and the aggregate membership is now over 500 and is rapidly increasing. The rooms are very largely used by trainmen and other railroad men, and the work of holding meetings, distributing papers, visiting the sick, etc., is carefully attended to. Social receptions are also held, and lectures given from time to time.

An additional branch is to be established at Green River as soon as rooms can be obtained there.

Testing the Forth Bridge.—The preliminary test of the Forth Bridge was made January 21. The two 1,700-ft. spans were tested by placing on the centers two trains, each made up of 50 loaded coal cars and three of the heaviest engines, the total load thus massed being about 1,800 tons, or more than double that which will be thrown upon the bridge in practice. The observed deflections were in accordance with the calculations with the engineers, and the bridge exhibited exceptional stiffness in all directions. It is also stated that during a heavy gale a few days before, when the wind gauges indicated a pressure of 37 lbs. per square foot, the maximum lateral movement of the great cantilever was less than one inch.

The first passenger train crossed the bridge January 24, carrying the engineers and a number of officers of the Great Northern & North British Companies. The train crossed at a speed of 12 miles an hour, and returned at about 15 miles an hour. The formal opening of the bridge is to take place March 4.

The Mittweida Viaduct.—The accompanying illustration shows a viaduct recently built over the Mittweida Valley on the Annaberg-Weiperter line of the Saxon State Railroad in Germany. As shown by the cut, it is a truss-bridge supported on



iron piers, and the German technical papers note it as a step toward the adoption of American methods of bridge construction. It was built under contract by the Königin-Marienhütte Company, at Cainsdorf, near Zwickau.

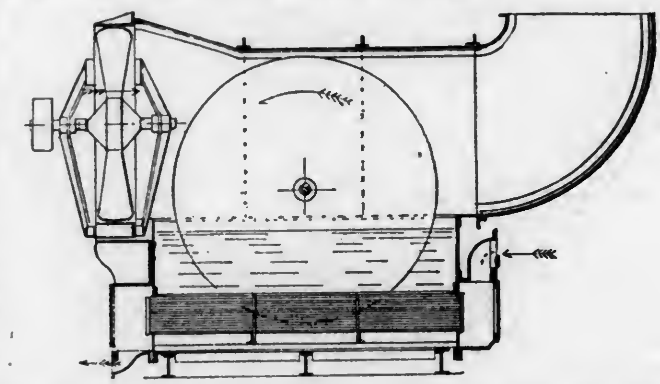
The total length of the viaduct is 237.5 meters (779 ft.). There are three spans of 12.5 m (41 ft.) each; four of 20 m. (65.6 ft.) each, and two of 25 m. (82 ft.) each. There are also eight short spans over the piers, two of them of 5 m. (16.4 ft.) each, and six of 10 m. (32.8 ft.) each.

The height of the piers varies, there being two of 12 m. (39.4 ft.); two of 15 m. (49.2 ft.); one of 20 m. (65.6 ft.); two of 25 m. (82 ft.), and one of 30 m. (98.4 ft.).

The total weight of the ironwork in the viaduct is 578 tons. It was erected in eight weeks by the contractors, in spite of very unfavorable weather, having been completed on December 1 of last year. It may be added that the viaduct is on a grade of 132 ft. to the mile.

A Railroad Monument.—The Pennsylvania Railroad Company is now placing a monument alongside the line of its Amboy Division, near Bordentown, to mark the location of the first mile of railroad laid in New Jersey, which was a section of the old Camden & Amboy Railroad, which, when first built, ran from Bordentown to South Amboy, and was for a time operated by horse-power. Some of the original spikes and flat plates used in the construction of the road have been preserved and will form a portion of the monument.

A New Condenser.—The accompanying illustration shows a novel form of condenser which has been used with considerable success in Germany and other parts of the Continent. The exhaust steam from the engine enters at the right of the engraving, and passes through a series of brass pipes immersed in



water, to which it gives up its heat. Between each section of tubes a number of galvanized disks are caused to rotate. These disks are cooled by a current of air supplied by the fan shown at the left of the illustration, and pass down into the water, cooling it by abstracting the heat given out by the exhaust steam and carrying it up where it is driven off by the air current. The disks serve also to agitate the water and thus aid it in abstracting the heat from the steam. With 85 per cent. vacuum the temperature of the cooling water was about 130° F., and a consumption of water for condensing is guaranteed to be less than a pound for each pound of steam condensed. For an engine 40 in. × 50 in., 70 revolutions per minute, 90 lbs. pressure, there is about 1,150 sq. ft. of condensing surface. Another condenser, 1,600 sq. ft. of condensing surface, is used for three engines 32 in. × 48 in., 27 in. × 40 in., and 30 in. × 40 in. respectively.—*The Steamship.*

THE RAILROAD AND

ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

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NEW YORK, APRIL, 1890.

FROM the time of the earliest explorations the long isthmus which connects North and South America has invited by its geographical conformation the building of an artificial channel to connect the Atlantic with the Pacific Ocean. The numerous projects for such a canal, more or less feasible in their nature have, apparently, at last reached their culmination in the Nicaragua Canal, which is now actually under construction.

In view of the fact that this great interoceanic channel will probably be completed in a few years, and in view also of its great commercial importance, a full account of the canal and of the many plans and surveys which led to the final adoption of the Nicaragua route will be of much interest. Such an account, arranged in a proper historical order, has been prepared for the JOURNAL by a writer who has had access to the best authorities and who has himself taken part in some of the surveys, and the first part will be found upon another page of the present number.

A GOOD deal of progress has been made lately in the introduction of electricity as motive power on street railroads, and the results obtained in many places have been very encouraging. Part of this is due, perhaps, to the experience gained on the first electric street railroads, and part also to the fact that electrical engineers and manufacturers are now realizing a fact which unfortunately some of them seem to have forgotten at first, and that is, that thorough workmanship and good design are as essential to the success of an electrical motor as to that of any other class of machinery. We do not wish to be unduly severe upon our electrical brethren, and indeed our strictures in this respect have been much more moderate than those of some of their own number. Many of them, both engineers and manufacturers, have realized this fact from the first, and with their designs and workmanship no fault can be found; but others, unfortunately, have apparently assumed that anything which could be called a motor would answer the purpose as long as it was run by electricity; and it is to this assumption that more than one of the failures which have been counted up against electric railroads are due. While cable traction seems at present to be the most desirable for roads of very heavy traffic, there remains for the electric car a wide field in this country, and it is very desirable that its success should not be impaired by carelessness in engineering.

THE West End Company in Boston is gradually getting its lines into working order with electric motors, and the system will be extended to one line after another until all are equipped, and animal power abandoned altogether. There has been a little friction, as might have been expected, but, on the whole, the electric motors are doing very well so far as they have been put in use. What trouble there has been seems to have been caused by an underestimate of the power required in bad weather, a mistake which can be remedied.

In New York the electric motor does not seem to meet with so much favor, although plans for dispensing with horses are not wanting. The Broadway line in that city is to be made a cable road, and the Third Avenue Company will adopt the same system as soon as certain legal obstacles can be overcome. These are the two lines having the heaviest traffic in the city, and their example will doubtless have much weight with the other companies.

IN Brooklyn as well as in New York the question of rapid transit is under discussion. The new elevated lines do not serve a considerable section of the southwestern part of the city, and there is a demand for a line along Atlantic Avenue. That it is needed no one seems to dispute, and the discussion is chiefly on the point as to whether it shall be an elevated or a depressed road. The contour of the ground is favorable to the tunnel, but it would be more costly than an elevated road, and popular preference in this country is usually for the latter form.

THE city of Chicago is soon to have its first elevated railroad, work having been begun on the South Side Elevated line. According to the contracts a mile of this road is to be finished during April, and its rapid extension is promised. This line is the beginning of a system of elevated roads to accommodate the city travel, and to take the place to some extent of the surface lines, which have proved themselves insufficient to accommodate the traffic.

THE second bridge over the Mississippi River at St. Louis will shortly be in use, the Union Bridge Company having completed the new Merchants' Bridge. The moving cause of the construction of this bridge was the fact that the St. Louis Bridge has now for some years been under the control of a single railroad interest, and that a second crossing was considered necessary to accommodate the business of the city and the railroads. It will be some weeks yet before the bridge is opened for traffic, for, while the structure itself is finished, the approaches, which have been built under a separate contract, are not quite complete.

THE opening of the Forth Bridge for traffic took place at the appointed time, and trains are now running regularly over this structure, which is for the present the greatest bridge in the world.

If the present stage of engineering requires any special designation, it might be called the era of great bridges. Late improvements in material, in methods of construction and in design have enabled engineers to undertake spans

which were considered impossible not long ago, and they have not been slow to take advantage of them. Taking recent examples in this country, there are the Poughkeepsie Bridge, the Cairo Bridge and the new bridge at St. Louis; the building of the bridge over the Mississippi at Memphis has been begun, and there is a fair prospect that the bridge over the Hudson at New York will be built after a time. That it is practicable no one seriously doubts.

A second bridge over the East River between New York and some point on the Long Island shore is also among the probabilities of the near future.

THE Ohio River has been unusually high this spring, wet weather and an early thaw having caused a flood which reached its greatest height—56 ft. 10 in. above low-water mark—at Cincinnati on March 1. There and at all the other towns on the river and its principal tributaries much damage was done. In due course the flood reached the Mississippi, and great injury to property is reported at and below Cairo. There has also been much damage from the breaking of levees on the lower river, so that the mild winter and wet spring of 1889–90 will be remembered for a long time.

THE great dam at Walnut Grove in Arizona, which was built about a year ago, has been partially destroyed, having given way under circumstances of which no very clear account has yet been received. The dam was built in the Walnut Grove Cañon and made a very large reservoir, in which the waters of the Hassayampa River were stored up to be distributed and used for irrigating purposes. In this way a large extent of land has already been prepared for cultivation, while preparations had been made to increase the area of irrigation considerably this season. So far as is yet known the failure of the dam seems to have been due to careless and hasty work in its original construction, and to a failure to provide sufficient waste-ways to draw off the overflow in a season of unusual rainfall like the present.

The accounts of this dam at hand are somewhat contradictory. It seems to have been well designed in the first place, but the original plans of the engineer were partially set aside on account of the expense of transporting material to the location of the dam. It was what is known as a rock-filled dam, but seems to have been somewhat carelessly built, with perhaps too steep a slope on the lower face. It is probable also that the waste-weir was not built in accordance with the engineer's plans, but was made of somewhat smaller capacity than he intended; and it may also prove that too great regard was paid to economy and the convenience of the contractors. Later accounts may give a fuller explanation, but it seems certain that the amount of water brought down by the river exceeded that observed in any previous season since the country was settled, and that the failure of the dam was due directly to the pouring of a large volume of water over its crest.

The loss to the owners of the dam is considerable, but the damage and loss of life caused by the breaking of the reservoir was not very large, because the valley below the dam is not thickly settled and contains no expensive buildings. It is understood that the dam is to be rebuilt.

THE production of pig iron continues to be very large. On March 1 there were in blast, according to the statement of the *Iron Age*, 343 furnaces with a total weekly capacity of 180,991 tons. This is an increase of 10 furnaces and 6,953 tons capacity since January 1, and of 35 furnaces and 31,216 tons capacity as compared with March 1, 1889. Several new furnaces of large capacity are nearly ready to start, so that a further increase is expected. While the stocks of iron reported on hand are large, they are not greater than might be expected, and the production does not seem to be in excess of the demand.

THE process of railroad consolidation and absorption has been continued in the Northwest by the sale of the Chicago, Burlington & Northern Railroad to the Chicago, Burlington & Quincy Company. The Burlington & Northern, which is a line from Chicago to St. Paul, was really built to be sold in this way, but various circumstances have made it necessary to postpone the transfer until now.

ANOTHER step in the same process is the transfer of the control of the Louisville, New Albany & Chicago Railroad to the Pennsylvania Company. This change was not expected, but was very quietly made, and did not become generally known until the annual meeting, when a board of directors in the Pennsylvania interest was chosen.

THE Louisville, New Albany & Chicago sale practically puts out of the way one of the competing lines from Chicago to Cincinnati and Louisville. The Burlington & Northern transfer, however, does not diminish the number of competing lines between Chicago and St. Paul, but only puts one of them into the hands of a stronger company, leaving the rate problem where it was before.

TWO cases of fast time are reported, both runs being made on the same day, March 10. On that day the Pennsylvania Railroad ran a special train from New York to Washington and return, for the purpose of carrying a theatrical company which was to perform in both cities on the same day. The train—which consisted of an engine, a combination car, passenger coach and dining-car—left Jersey City at 7.29 A.M. and reached Washington at 11.47; the total time was thus 4 hours, 18 minutes. The only stop made was in Philadelphia, where four minutes were spent in changing engines. The running time from Jersey City to Philadelphia was 97 minutes, or at the rate of 55.05 miles an hour; from Philadelphia to Washington, 157 minutes, or at the rate of 52.36 miles an hour; the total for the whole distance being 254 minutes, giving an average of 53.31 miles an hour. The return trip was in almost exactly the same time, the total time being 4 hours, 19 minutes; deducting a six-minute stop in Philadelphia, this left the running time 253 minutes, or one minute less than in the morning.

On the same day a special—consisting of an engine and one car—was run over the Bound Brook Line from Philadelphia to Jersey City in 85 minutes, or at an average speed of 63.53 miles an hour. The run from Wayne Junction to Bound Brook was made in 50 minutes, or at an average speed of 66 miles an hour.

THE use of corrugated tubular fire-boxes for locomotives is advocated in Germany by several engineers of standing, the advantages claimed being the lower first cost of boilers, owing to their simplicity of form, and the greater strength of a plain cylindrical boiler, which will permit the use of higher pressure—this last being an especial advan-

tage in the case of compound engines. Some illustrations of the forms of boiler proposed will be found on another page. It is understood that some tests of the corrugated fire-box are to be made on the Prussian State Railroads.

THE latest addition to the list of fast Transatlantic steamers is the *Normannia*, which was recently launched at Govan, Scotland, for the Hamburg-New York line. This ship is 500 ft. long, 57½ ft. beam, 38 ft. in depth and is registered at 8,500 tons. Like most of the large Atlantic steamers recently built, she has twin screws; each screw is worked by a triple-expansion engine with cylinders 40 in., 67 in. and 106 in. in diameter, and 66 in. stroke. Steam is supplied by nine double-ended steel boilers 16 ft. in diameter and 18 ft. long, each having eight corrugated furnaces; the working pressure will be 160 lbs.

The contract speed of the *Normannia* is 19 knots an hour, but her builders expect that she will exceed this, and that her engines will develop at least 14,000 H.P. The size of the ship is shown by the statement that she will have accommodations for 420 first-class, 172 second-class and 700 steerage passengers, making 1,292 persons in all who can be carried, besides the crew.

THE final test of the guns of the dynamite cruiser *Vesuvius* was made on the Delaware River near Chester, Pa., March 13. The tests were for speed in firing, made with dummy shells, and for range, the latter being made with loaded shells. Both were successful, and the range reached was 6,480 ft., or 400 yards over the mile required. The fuses worked well, and the shells exploded on time.

THE substitution of steam for compressed air in a gun intended to throw shells containing dynamite, or other high explosives, is proposed in France, the advantages claimed being the furnishing of power direct from the boiler, without the use of air-compressing machinery. The pressures usually carried in steam boilers would not be sufficient for this purpose, but the Belleville Boiler Company claims that it can furnish boilers of the Belleville type which can supply steam at a pressure of from 600 to 800 lbs., and which will be at the same time safe and easily handled. The experiment, it is stated, is to be tried by the French naval authorities.

IN the month of March two of the new ships for the Navy were launched—the *Newark*, which belongs to the class of large, swift, heavily armed cruisers like the *Chicago*, *Baltimore* and *San Francisco*, and the *Concord*, a light cruiser or gun-boat, of a type of which the *Yorktown* is the only representative now in service. The *Bennington*, a sister ship to the *Concord*, will follow early in the present month. These two gun-boats, while they could do little in action against a heavy battle-ship, may yet be exceedingly useful vessels in service, as, for instance, on the China and other Eastern stations where our Navy finds employment in time of peace, while in case of war they could also do good service against the commerce of an enemy and as assistants to the heavier fighting ships.

The next vessel for which contracts will be let is the 8,100-ton armored cruiser, which will be the largest ship yet undertaken for the new Navy, though her fighting power will be somewhat less than that of the *Texas*.

Setting aside the special coast-defense vessels or floating batteries, however, there is some doubt whether it will be advisable to go very much beyond this. The heavy battleships of England, France and Italy have not been entire successes, and there is high naval authority for saying that it is still an open question whether quickness in manœuvring may not be an offset to mere weight of armor and guns—in other words, whether, when modern naval constructions come to the test of actual battle, the victory will not remain with the swift rather than the strong.

THE GEOLOGICAL SURVEY.

THE topographical work of the United States Geological Survey continues to be pushed with much energy, and the record for the season which closed in December last is an excellent one, in spite of delays caused by much unfavorable weather. The assistants of the Survey were employed in no less than 23 States and territories, and the entire area covered by their work during the season was about 77,000 square miles. The office work was also well kept up, and the issue of the atlas sheets of the new surveys has been made promptly. The excellence of these maps is well known, and their mechanical execution is of a high order.

In the East the surveys have included 1,500 square miles in Maine, 450 in Vermont, 2,700 in Connecticut and 2,000 in Pennsylvania, the work in the last-named State having been chiefly in the anthracite coal region. The results of these surveys appear in 30 atlas sheets. These are all of uniform size, and for the Eastern States are on a scale of 1 : 62,500, with a contour interval of 20 ft. For the Central and Western States the maps are on a scale of 1 : 125,000, and each map includes about 1,000 square miles.

In the Southern Appalachian Mountain region the surveys extended through Kentucky, West Virginia, Virginia, Tennessee, North Carolina, South Carolina, Georgia and Alabama, covering about 12,000 square miles. Maps of this region are in much demand, on account of the rapid development of its mineral and other resources now in progress and the construction of numerous railroad lines through it.

In the Southwest a large force was employed, about 12,000 square miles having been covered in Kansas, 3,000 in Arkansas and 6,000 in Texas. The country surveyed in Arkansas was in the Ozark Hills, a district which has been heretofore almost unexplored.

In the Northwest about 700 square miles were surveyed in Wisconsin and 2,000 in Iowa. A special detailed survey of the iron range in the Upper Peninsula of Michigan has been begun, and was about half finished at the close of the season.

Perhaps the most important special work now in progress is the survey of the arid region of the Far West, which has been undertaken as a part of the irrigation survey. Last season's work covered 5,000 square miles in California and Nevada; 2,000 in Idaho; 2,000 in Montana; 4,000 in New Mexico and 24,000 in Colorado, making a total of 37,000 square miles in the belt which is chiefly to be benefited by irrigation. The results expected from this work are very considerable, and it is to be extended as fast as the means at command of the Survey will permit.

It is hardly necessary to say that the work here recorded has been done with the care and thoroughness which have always characterized the methods of the Geological Survey. Of the excellence of its maps we have already spoken, and when the series is completed they will form an atlas of which the United States may well be proud.

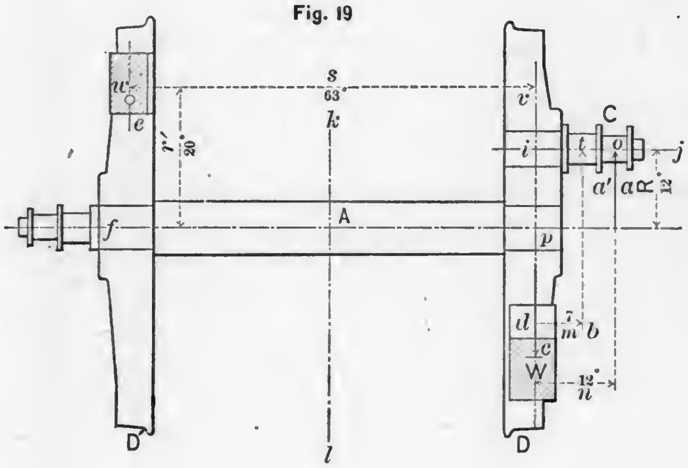
COUNTERBALANCING THE REVOLVING AND RECIPROCATING PARTS OF LOCOMOTIVES.

(*Concluded from page* 100.)

IF the counterweights which are used to balance the revolving and reciprocating parts of locomotives, could be placed axially opposite to the crank-pin, the horizontal disturbing action of these parts could thus be entirely neutralized or balanced. There is a practical difficulty in doing this, because such weights must be put between the spokes of the wheels, and in that position they are not axially opposite to the point where such weights act on the crank-pin, as is shown in fig. 19, in which *C* is the crank-pin and *W* the counterweight. The center of gravity *c* of the latter is 12 in. nearer to the center, line *k l* of the engine than the center of the journal *o* of the crank-pin is, as indicated by the dimension-line *n*. If, now, it is assumed that fig. 19 is a plan—that is, that we are looking down on the wheels and axle, and that the coupling-rod is attached to the outside journal *o* of the crank-pin, its weight would then exert a centrifugal force against the pin in the direction indicated by the dart *a* and the counterweight *W* would exert a force in the opposite direction, as indicated by the dart *d*.

To simplify the illustration, it will be supposed that the center-line *f p* of the axle, the line *i p* drawn through the center of gravity of the counterweight, and the center-line *i j* of the crank-pin are represented by the dark line *f p i j*, fig. 20, and that this line represents a bent lever of the form shown. It is now evident that if there is a force *a* acting against the lever at *o*, and another at *d* acting at *p* in the opposite direction, that the tendency of these two forces will be to turn the lever into a position indicated by the dotted lines *g p i j*; as these two forces are not in equilibrium. If, however, we could apply a third force *e*, which would act at the opposite end *f* of the lever, in the same direction as *a*, and if $e + a = d$ and if *e* and *a* be properly proportioned to each other, then the forces acting on the lever would be in equlibrium, or would balance each other. In the same way the forces *a* and *d* acting on the crank-pin and wheel, as represented in fig. 19, tend to turn the wheels and axle about a vertical axis of least resistance, and they thus cause what is called "nosing" and rolling of the locomotive. For these reasons it is desirable to introduce a force at the opposite end *f* of the axle, which will act in a similar way to *e* in fig. 20. This end can be accomplished by putting a supplementary counterweight *w*, fig. 19, in the wheel *D'* and on the same side of the axle that the crank-pin *C* is on. The centrifugal force of the supplementary counterweight will act in the direction of the dart *e*. If, now, *w* is so proportioned that the force $a \times n = e \times s$ (*s* being the horizontal distance of the center of gravity of *w* from the center of gravity of *W*), and if *W* be made of such a weight that $d = a + e$, then the wheels will be perfectly balanced.

Fig. 19



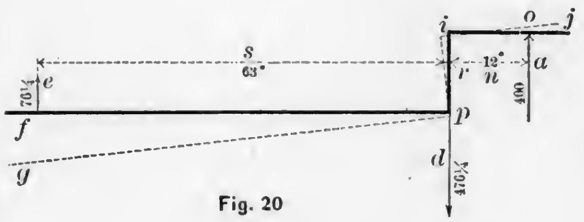
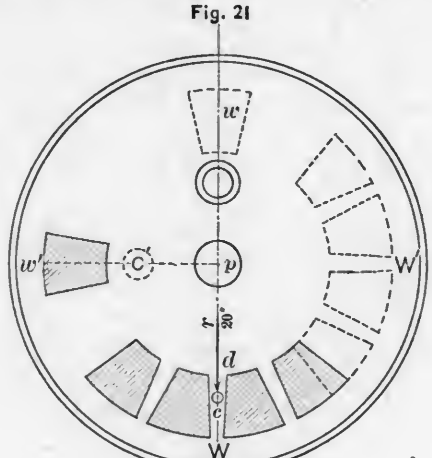


Fig. 20

Fig. 21



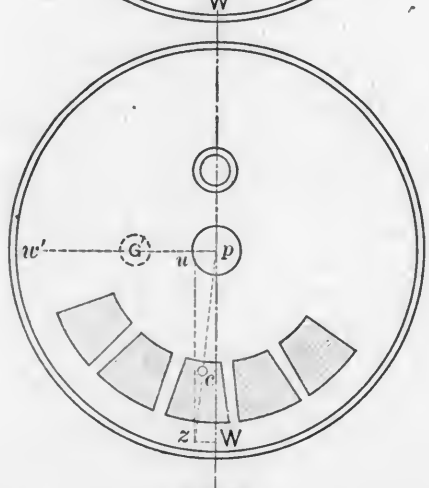


Fig. 22

To calculate the weight of *W* and *w*, we must first know the weight of the coupling-rod or rods attached to the journal *o*, and then calculate the centrifugal force of this weight exerted at *o*. As coupling-rods are connected to two wheels, a counterweight must be provided in each wheel for *one-half* the weight of the coupling-rod or rods attached to each wheel. In the present example it will be assumed that we have a four-wheeled coupled engine and only one coupling-rod on each side, and that the weight of each is 240 lbs., and therefore that we must calculate the

centrifugal force of 120 lbs. exerted at *o*, fig. 19. The rule for calculating the centrifugal force was given in the first article of this series, published in the February number of the JOURNAL.

In making the calculations we may assume any speed, say 60 miles per hour, and that the wheels are 62 in. diameter and the stroke of the pistons 2 ft. The wheels would then revolve 325 times per minute. By the rule given we would then have:

$120 \times 325^2 \times 1 \times .00034 = 4{,}309.5 =$ the centrifugal force exerted at *a*. As the horizontal distance *n* of *a* from the center of gravity of *W* is 12 in. and the distance *s* between the centers of gravity of the weights *W* and *w* is 63 in., we must ascertain the force which must be exerted at *e* and at *W* to balance 4,309.5 lbs. at *a*. As *a* and *e*, by the principle of the lever, are inversely proportional to the length of the lever arms *s* and *n* we will have:

$$\frac{4{,}309.5 \times 12}{63} = 821$$

= the centrifugal force at *e*. To balance *a* and *e* *d* must be equal to $a + e$ — that is, $4{,}309.5 + 821 = 5{,}130.5 =$ the force *d*, which must be exerted by the counterweight *W*. The problem, then, is to ascertain the weights *w* and *W*, which at a speed of 60 miles per hour will exert centrifugal

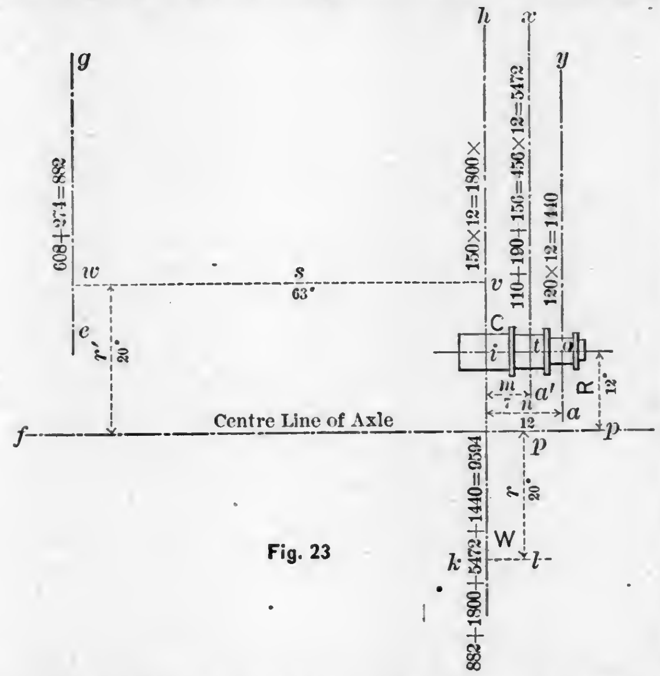


Fig. 23

forces *e* and *d* of 821 and 4,860.5. By expressing the rule for calculating centrifugal force algebraically, the solution will be apparent. Thus, let

$W =$ weight in lbs. of the revolving part.
$N =$ number of revolutions per minute.
$R =$ radius or distance in feet from the center of motion.
$.00034 =$ a constant.
$F =$ centrifugal force.

Thus the formula for centrifugal force becomes:

$$W \times N^2 \times r \times .00034 = F$$

$$\text{and } W = \frac{F}{N^2 \times r \times .00034}.$$

Or, stated arithmetically, to ascertain the weight required to produce a given centrifugal force:

Multiply the square of the number of revolutions per minute, the radius or distance in feet of the center of gravity of the weight from the center of motion, and .00034 together, and divide the centrifugal force by the product. The quotient will be the required weight.

Therefore the distance *c p*, of the center of gravity, of the counterweight from the center of the axle being equal to 20 in. and that of *w* the same, we will have:

$$\frac{821}{325^2 \times 1\tfrac{2}{3} \times .00034} = 13.7 = w,$$

$$\text{and } \frac{5{,}130.5}{325^2 \times 1\tfrac{2}{3} \times .00034} = 86 = W.$$

It remains to calculate the counterweights required to balance the centrifugal force exerted by the reciprocating parts and main connecting-rod on the journal *t* of the crank-pin. Before making this calculation it must be decided what proportion of the reciprocating parts will be counterbalanced. It will be assumed that, by balancing one-half of them we will get the best results, and that the back end only of the main connecting-rod may be regarded as a revolving weight, and that the weights of the different parts are as follows:

	Revolving weights. lbs.	Reciprocating weights. lbs.
Crank-pin boss	150	....
Crank-pin	110	....
Back end of main connecting-rod	190	....
Front end of " " "	....	150
Cross-head	....	174
Piston and piston-rod	....	300
Totals	450	624

If we balance one-half the weight of the reciprocating parts and divide that half equally between the two wheels, and omit the crank-pin boss, we will have $300 + 156 = 456$ lbs. as the total weight attached to the journal *t* to be balanced. Observing that the horizontal distance *m*, fig. 19, of the center of gravity of *W* is only 7 in. from the middle of the journal *t*, and calculations similar to the preceding will show that the weights at *w* and *W* to balance 456 lbs. at *t* will be

$$w = 30.4$$
$$W = 304.$$

In addition thereto the crank-pin boss must also be balanced, but as its center of gravity and that of the counterweight *W* are in the same plane, no supplementary counterweight is needed. Its counterweight is calculated by multiplying its own weight by the stroke $R = 12$ in. and dividing by the distance *r* of the center of gravity of *W* from the center of the axle = 20 in. We will therefore have:

$$\frac{150 \times 12}{20} = 90.$$

By adding all these weights together we have:

$$w = 13.7 + 30.4 = 44.1 \text{ lbs.}$$
$$W = 86. + 304 + 90 = 480. \text{ lbs.}$$

In order to get a sufficient amount of counterweight in a wheel it is essential to divide the main counterweight between a number of spokes, as shown by the shaded areas at *W* in fig. 21. The supplementary counterweight in the opposite wheel would be in the position shown by dotted lines at *w*. If the opposite crank-pin is in the position shown by the dotted circle *C'*, then its main counterweights will be in the opposite wheel, in the position indicated by the dotted lines at *W'*, and its supplementary counterweight will be in the nearest wheel, as shown by the shaded area at *w'*. It will be seen that there will

thus be two sets of counterweights in each wheel. Those in the nearest wheel are shown by the shaded areas, and those in the opposite wheel by the dotted lines. The centrifugal forces of the two sets in the nearest wheel act in the direction of the lines $p\ W$ and $p\ w'$, drawn through the center of the axle and the center of gravity of the counterweights. By the principle of the parallelogram of forces we can resolve the effects of these two separate sets of counterbalances into a common resultant. As the centrifugal force of each will be proportional to its weight, if their centers of gravity are at equal distances from the center of the axle, if to any convenient scale we lay off on $p\ W$, fig. 22, a distance, $p\ W$, equal to the counterweights W, and on $p\ w'$, the direction in which the force of w', fig. 21, acts, a distance, $p\ u$, = to the weight w', then if we construct a parallelogram $u\ p\ W\ z$, with $u\ p$ and $p\ W$ as sides, and draw a diagonal $p\ z$, it will represent the magnitude and direction of a resultant of the two forces W and w'. If, then, we arrange a single counterweight, or a group of them, with their common center of gravity c on the line $p\ z$, as shown in fig. 22, they will act the same as the two separate systems W and w, shown in fig. 21, would. The counterweights may therefore be arranged as shown in fig. 22.

If the main rods took hold of the outside journal of the crank-pin as they do in Mogul, Consolidation, and some other classes of locomotives, obviously the supplementary weight must be heavier, because the combined weight of the back end of the main connecting-rod and the reciprocating parts is greater than that of the coupling-rods, and the supplementary counterweight must be increased the greater the distance, m or n, fig. 19, that the point of attachment to the crank-pin is from the center of gravity of the main counterweight. On most four-wheeled coupled engines in this country which have a truck, the coupling-rods are connected to the outside journals of the crank-pins.

The ordinary rule which is employed for calculating counterweights, is the following :

RULE I.

Find the separate revolving weights, in pounds, of crank-pin, crank-pin boss, coupling-rods, and back end of connecting-rod for each wheel; also the reciprocating weight for the piston and appendages, and the front end of the connecting-rod. Take one-half of the reciprocating weight and divide it equally between the coupled wheels, and add the part so allotted to the revolving weight on each wheel; the sums so obtained are the weights to be balanced at the several wheels. Multiply these weights by the length of crank in inches, and divide by the distance in inches of the center of gravity of the space to be occupied by the counterweight from the center of the axle. The result will be the counterweight, in pounds, to be placed diametrically opposite to the crank-pin.*

This rule takes no account of what may be called the transverse disturbing action of the revolving and reciprocating parts, and their counterweight, which is due to their revolution in different planes or at different distances from the center of the engine, which has been explained in this article. Before giving the rule which takes this action into account, it should be remarked that it may be assumed, without material error, that the center of gravity of a crank-pin, like that shown in fig. 19, is on the vertical line $t\ b$ drawn through the middle of the journal t, and the center of gravity of the crank-pin boss is on the line $v\ W$ drawn through the center of gravity of the counterweight. The reasoning which has been given regarding the transverse action of the counterweights may then be reduced to the following rule for calculating them :

RULE II.

1. *Ascertain the weights, in pounds, of the revolving parts on each journal of each crank-pin.*

2. *Then on a drawing of the crank-pin, fig. 23, lay off a line* v W *at right angles to the axis of the pin and passing through the middle, or the center of gravity of the main counterweight. Then draw similar lines* x a' *and* y a *through the middle of the journals* t *and* o, *and lay off* f p *the center-line of the axle, and the horizontal lines* w v *and* k l *drawn through the centers of gravity of the two counterweights* w *and* W. *Also for convenience mark on the drawing the distances* s, m, n, r, *and* r'.

3. *Set down the weights of the revolving parts on the respective lines drawn at right angles to the axis of the crank-pin.**

4. *Take one-half† of the whole weight of the reciprocating parts, on one side of the engine, and divide it equally between the coupled wheels on one side, and mark the weight‡ so allotted on the line drawn through the middle of the main journal of the crank-pin.*

5. *The weights thus set down on each line should then be added together and the sum multiplied by* R = *half the stroke in inches.*

6. *Then multiply each of these products, excepting the one on the line* h i, *by the distance* (m *or* n) *in inches, of the respective weights from the line* v W, *drawn through the middle of the counterweight* W, *and divide by* s—*the transverse distance between the centers of the two counterweights—and set the quotients down on the line* g w, *and add them together.*

7. *Take all the final figures on the vertical lines* g h x *and* y *and set them down on the line* i W *and add them together. Then divide the sums on* i W *and* g w *by* r *and* r', *in inches, and the quotient will be the weights of* W, *the main counterweight, and* w, *the supplementary counterweights, respectively.*

Having ascertained the main and supplementary counterweights, they can both be combined in one by the method already explained. By adding the two together the combined weight in each wheel, by Rule II, would be 524.1 lbs. If we calculate the weight by the first rule it will be found that it gives 435.6 lbs. It will thus be seen that the second rule gives a somewhat heavier counterweight than the first. While this promotes the horizontal stability of the engine, it increases the vertical disturbance. It will be noticed that by Rule II the supplementary counterweight is less than one-tenth that of the main one. If, however, the main connecting-rod was attached to the outside journal o of the crank-pin, and if this was increased in length, as it often is on Mogul and Consolidation engines, then the supplementary weight would bear a larger proportion to the main one than in the example selected, and it

* From one-half to three-quarters should be taken. No exact rule can be given for this.

* In this case the crank-pin boss = 150 lbs. on vertical line h, the crank-pin = 110 lbs., and the back end of main connecting-rod = 190 lbs. on x, and one-half the coupling-rod = 120 lbs. on y.

† Or any other proportion that may be decided upon.

‡ As given above = 156 lbs.

would then be more important that provision should be made to balance the disturbance which requires this larger weight. As already remarked, Rule II gives heavier counterweights than the first one. They cause more vertical disturbance than lighter weights would, and this disturbance increases very rapidly with the speed. As the main connecting-rods of nearly all passenger locomotives are attached to the inside journals of their crank-pins, the inference might be drawn that Rule I should be used for passenger engines or those whose main connecting-rods are attached to the inside journal, and Rule II is best adapted for freight engines which are connected to the outside journals.

NEW PUBLICATIONS.

Wie soll Tarifirt Werden? Ein Beitrag zur Lösung der Frage der Personentarif Reform. Vienna, Buda-pest and Leipzig; A. Hartleben.

This is not—as a too free rendering of the German title might indicate—a pamphlet on "Tarift Reform," as we understand it in this country; it is a contribution to the great discussion which is now occupying the railroad authorities of Germany and Austria, and naturally the public also, on Passenger Rates and the best method of equalizing and adjusting them. The present book considers the question from several points of view, and especially in relation to the "Zone System," lately adopted on the Austro-Hungarian railroads. Perhaps the intent can best be described by the following extracts from the preface of the anonymous author:

The reform of the present irrational schedules of passenger rates on the railroads is one of those questions a final answer to which can no longer be set aside as out of order, since it is rooted deep in the self-interest of almost every individual.

The Press of all Europe has entered the opening wedge by almost daily discussions; the representatives of the people in almost every country have taken it up as part of the business on their programme; the railroad managements, which acknowledge that these demands come before all others, have employed themselves for some time past with the study.

While the question does not yet—and does not at present seem likely to—engage public interest here as in Europe, there is little doubt that our passenger tariffs are as full of inconsistencies as those of Europe, and that a reform would benefit all parties. Under our system a general movement would be much more difficult here than there; but discussion of the subject will do no harm, and the pamphlet under consideration is well worth reading in this relation.

Handbook of Freight Accounts: by Marshall M. Kirkman. Chicago; published for the Author.

This latest addition to Mr. Kirkman's series of books on Railroad Accounts treats of the methods of handling freight; the theory and practice of accounts; rules and regulations governing agents, and the returns to be made by them. While the book outlines a particular system of accounts, he expressly disclaims any wish that a single system should be prescribed for all railroads, believing that such a plan would stop development, prevent progress and forbid individual effort and further improvement. All that is to be asked is that results should be stated uniformly, leaving to the discretion of each company the best method of arriving at them.

While this is true, it is also true that there is now altogether too wide a divergence in methods, and that some general understanding—which does not at all imply a general acceptance of a cast-iron system—is very desirable. The present book may be of much service in bringing this about, if properly received and used.

To criticise the book in detail would hardly be in place here; it is enough to say that Mr. Kirkman's authority as a writer—indeed the only writer—on Railroad Accounts is so high that what he says is pretty sure to find a respectful hearing among those to whom he addresses himself. The book contains 157 pages of text, an appendix containing 51 pages of blanks and forms, and a sufficient index. It is published in uniform style with the preceding books of the series, but like its predecessors is entirely independent and can be used without reference to the others.

The Danger and Wrong of Existing Legislation Concerning Railroads: a Review of its Results. Chicago; the *Railway Age* Publishing Company (price, 25 cents).

This pamphlet is a reprint of the remarks of Mr. T. B. Blackstone, President of the Chicago & Alton Railroad Company, which were appended to the annual report of that company, recently issued. The summary of these remarks published in the papers attracted much attention, and the *Railway Age* has done a service to railroad men and others interested by publishing them in a form which is accessible to every one.

Mr. Blackstone complains bitterly of the general policy adopted by the National Government and the States toward railroad corporations for several years past, and charges that the result of this policy has been to make a large part of the railroad property of the country unprofitable. The remedy suggested is a radical one, being the ownership of all the railroads by the National Government.

Not every one will be willing to admit Mr. Blackstone's premises, and very few will be ready to accept his startling conclusion. His standing and reputation as the manager for many years of a very successful railroad company, however, give his words weight, and, whether we agree with him or not, his argument is a contribution to the literature of the question which deserves reading.

We agree with the publishers in hoping that it will call out a reply from some of those who are competent, from experience and standing, to discuss the subject with authority.

BOOKS RECEIVED.

Selected Papers of the Institution of Civil Engineers. London, England; published by the Institution. The present issue includes the following titles: Compound Locomotives, by Ernest Polonceau; Piers and Harbors on the North and West Coasts of Scotland, by James Barron; Hydraulic Packing Presses, by Charles Hopkinson; the Tacheometer, by Neil Kennedy; Inland Steam Navigation in India, by Alexander Joseph Bolton; Scientific Fortification in China, by William M. McDowdall; Jetties in the United States, by Professor Lewis M. Haupt; Abstracts of Papers in Foreign Transactions and Periodicals.

Transactions of the Liverpool Engineering Society. Volume IX., Session of 1888, and Volume X., Fifteenth Session: Edited by J. H. T. Turner, Honorary Secretary. Liverpool, England; published by the Society.

Reports of the Consuls of the United States to the Department of State: Nos. 110 and 111, November and December, 1889. Washington; Government Printing Office. The present volume of Consular Reports relates entirely to the subject of Mortgages in Foreign Countries.

Annual Report and Statements of the Chief of the Bureau of Statistics, Treasury Department, on the Foreign Commerce and Navigation, Immigration and Tonnage of the United States, for the Fiscal Year ending June 30, 1889: S. G. Brock, Chief of Bureau. Washington; Government Printing Office.

Third Annual Report of the Board of Mediation and Arbitration of the State of New York; for the Year 1889: William Purcell, Gilbert Robertson, Jr., Florence F. Donovan, Commissioners. Albany, N. Y.; State Printer.

ANNUAL REPORT OF THE STATE BOARD OF ARBITRATION OF MASSACHUSETTS FOR THE YEAR 1889. CHARLES H. WALCOTT, RICHARD P. BARRY, EZRA DAVOL, MEMBERS OF THE BOARD. Boston, Mass. ; State Printers.

EIGHTEENTH ANNUAL REPORT OF THE SUPERINTENDENT OF WATER WORKS, BAY CITY, MICH., FOR 1889 : E. L. DUNBAR, SUPERINTENDENT. Bay City, Mich. ; published for the City.

QUARTERLY REPORT OF THE CHIEF OF THE BUREAU OF STATISTICS, TREASURY DEPARTMENT, ON IMPORTS, EXPORTS, IMMIGRATION AND NAVIGATION : FOR THE QUARTER ENDING SEPTEMBER 30, 1889. Washington ; Government Printing Office.

SEVENTH ANNUAL REPORT OF THE BOARD OF RAILROAD COMMISSIONERS OF THE STATE OF KANSAS, FOR THE YEAR ENDING DECEMBER 1, 1889 : ALBERT R. GREENE, JAMES HUMPHREY, GEORGE T. ANTHONY, COMMISSIONERS. Topeka, Kan. ; State Printer.

CORNELL UNIVERSITY, COLLEGE OF AGRICULTURE : BULLETIN OF THE AGRICULTURAL EXPERIMENT STATION. No. XV., DECEMBER, 1889. Ithaca, N. Y. ; published by the University.

AUTOMATIC BRAKES AND COUPLERS ; PROGRESS MADE IN THE EQUIPMENT OF FREIGHT CARS. Pittsburgh, Pa. ; issued by the Westinghouse Air Brake Company. This pamphlet gives a statistical account of the progress made up to the close of 1889 in equipping freight cars in this country with automatic brakes and couplers. It contains a map of the United States, showing the railroads on which the automatic brake has been adopted for freight equipment.

ELECTRICAL ACCUMULATORS OR STORAGE BATTERIES : BY PEDRO G. SALOM. Philadelphia ; published for the Author. This is a reprint of a paper read before the American Institute of Mining Engineers at the Washington Meeting in February.

AN IMPROVED SYSTEM IN THE CONSTRUCTION OF RAILROAD CARS : BY MAX A. ZÜRCHER, ASSISTANT ENGINEER CANADIAN PACIFIC RAILWAY. New York ; published for the Author. This pamphlet describes a new system of metallic framing for cars, the invention of Mr. Zürcher, who has had many years' experience on bridge and railroad work.

SILICATED IRON AND STEEL : CIRCULAR No. 3. Chicago ; issued by the Mullins Silicated Iron & Steel Company.

BUCKEYE PORTLAND CEMENT : MANUFACTURE, TESTS AND USES. Bellefontaine, O. ; issued by the Buckeye Portland Cement Company.

SOLID EMERY WHEELS AND GRINDING MACHINES, KNIFE-SHARPENERS, OIL OR WHETSTONES, DIAMOND TOOLS AND EMERY : CATALOGUE. Stroudsburg, Monroe County, Pa. ; issued by the Tanite Company.

ABOUT BOOKS AND PERIODICALS.

THE quarterly JOURNAL of the American Society of Naval Engineers for February has several valuable papers presented at meetings of the Society. These include Speed Trials of Fast Ships, by Assistant Engineers Harold P. Norton and Walter M. McFarland ; Marshall Valve Gear, by Passed Assistant Engineer Ira N. Hollis ; Test of Worthington Pumping Engines, by Chief Engineer Isherwood ; descriptions of the new torpedo-boat *Cushing* and of the second trial of the *Baltimore*, giving the full results then obtained.

It is announced that the ELECTRICAL ENGINEER, the oldest periodical in its department in this country, will be published weekly hereafter, instead of monthly, the change beginning with April. The management of the paper will be in the hands of Messrs. George M. Phelps, T. Commerford Martin and Joseph Wetzer. We wish our electrical contemporary the fullest success, and do not doubt that it will continue to keep the high reputation it has always held and deserved in its field.

The Gross and Net Gain of Rising Wages is a very thoughtful and well-considered article in the POPULAR SCIENCE MONTHLY for March. The Editor's Table and the correspondence contain, as usual, some bright and interesting discussions.

Mr. Leo Von Rosenberg, New York, has now in press the WASHINGTON BRIDGE, a monograph by Mr. William R. Hutton, Chief Engineer. This bridge, which crosses the Harlem River Valley at 181st Street, New York, is a notable example of bridge construction and well worth careful study by engineers. The book will contain a full description, with 24 large engravings, made from photographs taken during and after construction, and a large number of plates showing very fully the details of the masonry and superstructure. It will be printed in the very best manner, and will make a very handsome volume.

The second article on John Ericsson in the March number of SCRIBNER'S MAGAZINE is devoted to his great inventions. Among the engravings are views of the *Novelty* locomotive and of the first steam fire-engine, and fac-similes of the original pencil sketches for the *Monitor*, made in 1854.

The article on Creedmoor and the National Guard, by Lieutenant W. R. Hamilton, in OUTING for March, is an account of what has been done in New York in the very important matter of improving the marksmanship of the State troops. The number generally has a breezy, out-of-doors flavor about it which reminds us that Winter is over and the season for open-air sports is near.

In HARPER'S MAGAZINE for March, the venerable "Easy Chair" speaks of some aspects of city engineering as seen in New York streets. The army series is continued by General Merritt's very interesting article on the Army of the United States, which is chiefly historical and descriptive.

The new Boston magazine, the ARENA, seems determined to open a field peculiarly its own—the free discussion of questions of public interest on all sides, giving the greatest latitude to the expression of opinion. In the March number, as in the preceding ones, the writers are all people of mark, and, whether the reader agrees with them or not, he must admit that they all have something to say and present their arguments ably, if not convincingly.

Many engineers will be interested in Major J. W. Powell's article on the Irrigable Lands of the Arid Region in the March CENTURY. Engineers, and a good many others also, should see Mr. Shaw's article on Glasgow—a Municipal Study. This account of the methods adopted in the great Scotch city deserves a careful reading.

Among the articles in the SCHOOL OF MINES QUARTERLY for January are Public Street Lighting in New York, by E. G. Love ; Patent Equivalents, by Emil Starek ; Irrigation Engineering, by H. M. Wilson, and several others of special interest.

The London INDUSTRIES has issued a voluminous special number giving an account of the Forth Bridge, both historical and descriptive. It is profusely illustrated, the engravings showing the bridge as completed, the work in various stages of progress and many details of construction. This special number is worth preservation, as it gives in connected form an account of the great bridge, and many facts which would otherwise have to be hunted up through many papers.

The London ENGINEERING also issues a special Forth Bridge number, in connection with the opening of the bridge. This is illustrated, most of the engravings having been published heretofore in the columns of the paper ; but they are now brought together under one cover, in such a way as to make them convenient for keeping and reference.

GRÜSON'S QUICK-FIRE GUNS.

(From the London *Engineer*.)

We have received a very complete report in English of Herr Grüson's new quick-fire guns. This has a special interest, inasmuch as he has developed an entire system of guns, carriages and shields. It appears that Grüson, at an early stage of his inquiry, concluded that five classes of quick-fire guns were necessary in addition to machine guns. Many of these quick-fire guns have been supplied to governments, and have borne severe tests for endurance; guns from which 2,000 rounds have been fired have shown a complete absence of any trace of erosion. It is laid down that the crucible steel used in the pieces must bear a strain of 35.3 tons per square inch, with 15 per cent. extension and an elastic limit of 16.5 tons per square inch. The standard thus indicated has, however, in all cases been greatly exceeded. The five guns in question are as follows: 1. The 3.7 cm. (1.46 in.) gun, 23 calibers long; 2. The 5.3 cm. (2.09 in.) gun, 24 calibers long; 3. The 5.3 cm. (2.09 in.) gun, 30 calibers long; 4. The 5.3 cm. (2.09 in.) gun, 39 calibers long; 5. The 5.7 cm. (2.24 in.) gun, 25 calibers long.

Fig. 1.

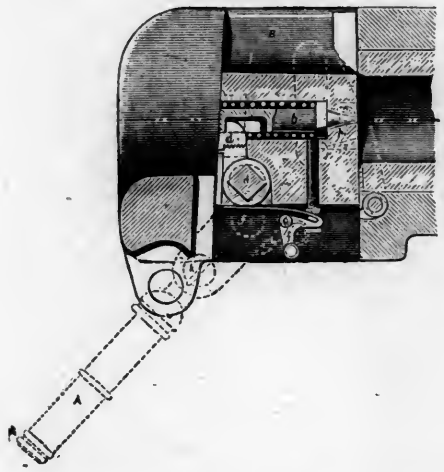


Fig. 2.

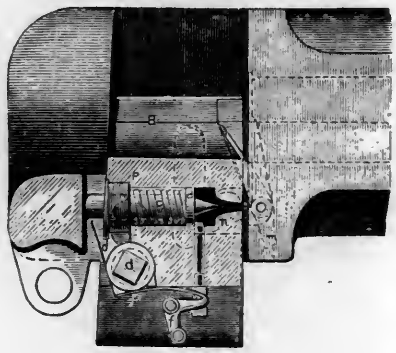
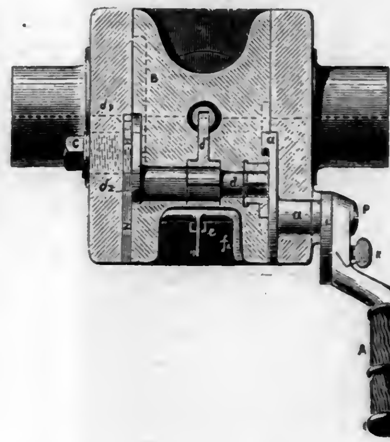
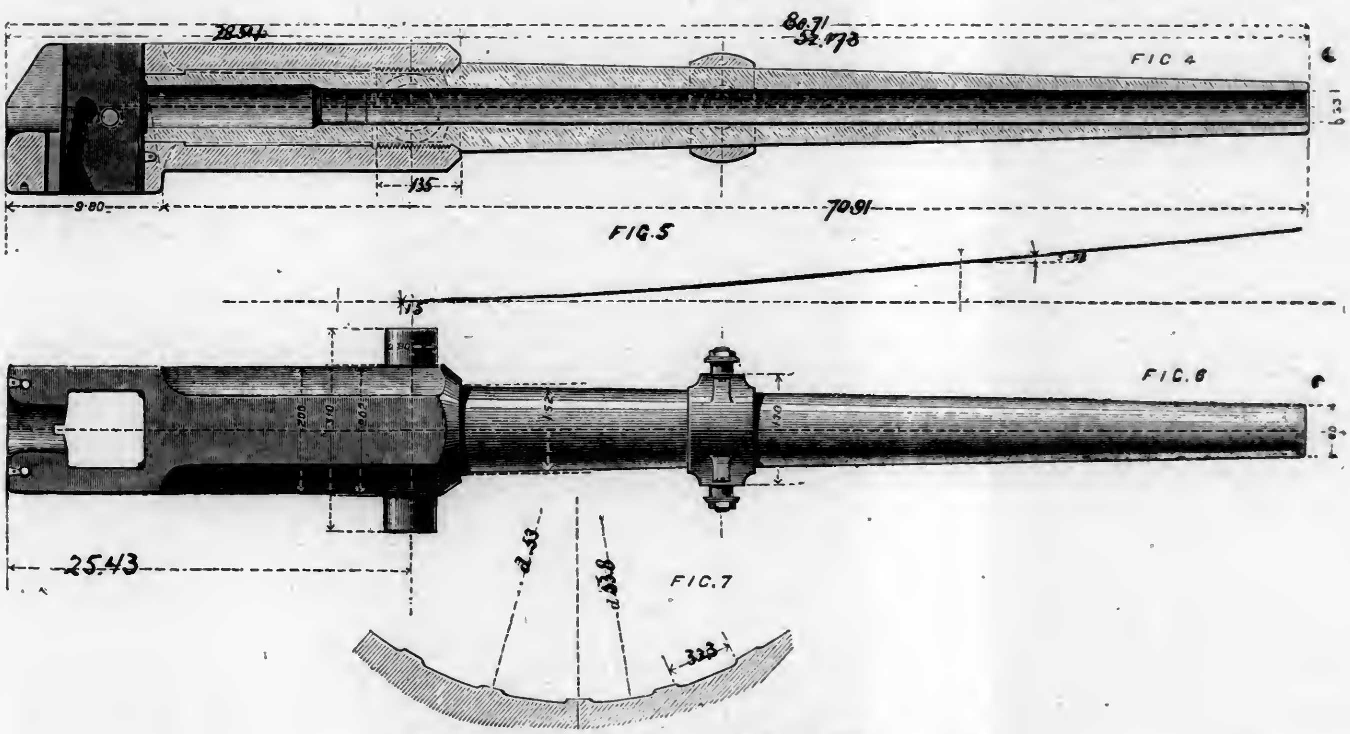


Fig. 3.



The breech mechanism is common to all; it has been found to work with ease and rapidity, a rate of from 35 to 40 rounds per minute having been realized. The cocking of the striker is effected by the downward movement of the breech-block. They are of all kinds only 19 pieces in the mechanism, which is shown herewith in figs. 1, 2 and 3. The general character of the action can be seen in these cuts without going into minute detail. The block *B* is hollowed out at the top, as shown in fig. 3, for the passage of the ammunition. It slides up and down in its vertical slot when the hand-lever *A* is worked. Its downward movement is limited by a screw *C*, working in a vertical groove *y*. The striker *b* is actuated by a spiral spring *c*, and is moved by levers *d d*, on the shaft *d*. The trigger-pin *e* is acted on by the flat spring *t*. It may be fired by a lanyard, which draws back the trigger and releases the striker, or by special levers fitted on.



THE GRÜSON RAPID-FIRE GUN.

The piece is worked by two men. One lays, loads and fires, and one hands the ammunition. The gun is in each case made in two parts of forged crucible steel, the barrel and the breech-piece, which is screwed on to it, forming

a jacket. Figs. 4, 5, 6 and 7 show the longest 5.3-cm. piece, the fourth gun of those we have enumerated, which appears to be the best to take as an example. The 5.7-cm. gun is a comparatively short piece. The total length of

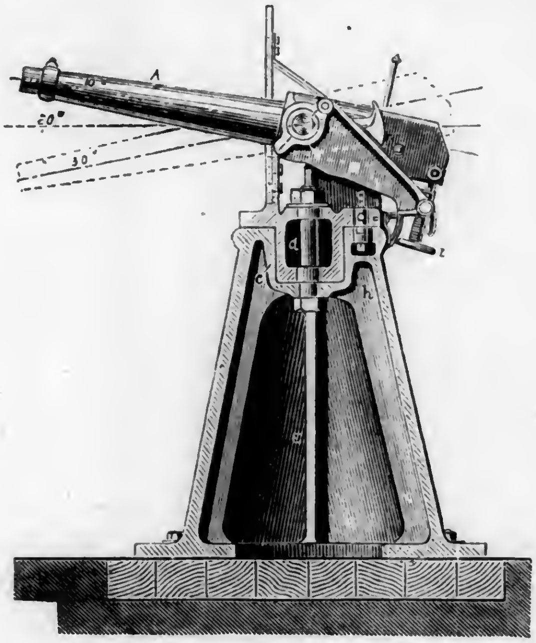


Fig. 8.

the barrel of this 5.3-cm. gun is 73.03 in. The rifling consists of 24 grooves of the section shown in fig. 7. The twist is right-handed, increasing from 1 in 165 to 1 in 30 calibers. The entire gun is 80.7 in. long. The diameter of the powder chamber is 2.52 in., that of the bore being 2.087 in. The gun weighs 595.2 lbs., or with breech-block 639.3 lbs. The charge is 1.565 lbs. The shell weighs 4

FIG 9.

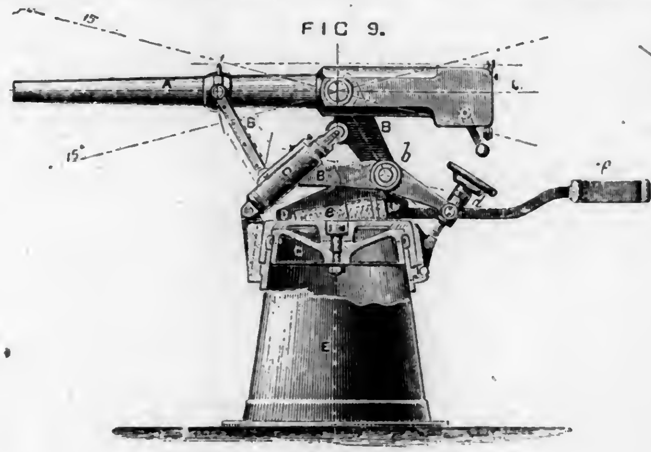
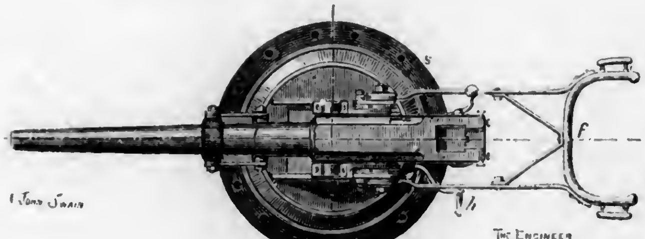


FIG 10.



lbs. In one minute 26 rounds are fired, amounting to 104.3 lbs. The muzzle velocity is 1,969 ft. per second, and the energy of fire per minute 2,804 foot tons. The maximum pressure in the bore is 12.7 tons per square inch.

This gun is intended for naval service. It is mounted on non-recoil cone mounting, similar to that for the 5.3-cm. gun of 24 calibers length, which is shown in fig. 8. Here the gun *A* is on a carriage *B*, with a cast-steel pivot turning on a socket *e* cast in one piece with the cone. The carriage is screwed down by a bolt to prevent its jumping from its socket. Training is effected by a hand-wheel at the further side of the carriage, with box *g* and pin. A pointer is screwed on to the carriage for indirect fire, which indicates the training on a graduated training plate. Elevation is given by a hand-wheel *i* by a double-adjusting screw. The degrees of elevation are read off on the carriage, which is constructed to give 15° elevation and 10° depression. A shield is screwed on to the carriage. The weight of the upper part of the cone mounting is 353 lbs., and of the stand, 794 lbs.

A pivot carriage with an ordinary recoil slide is in course of construction. There is a pivot mounting in which the gun is carried on a jointed parallelogram kept in position by a hydraulic press, its base being movable about a pivot or cone. In fig. 9, *A* is the gun; $B\ B^1\ B^2$ the carriage; *C* is the pivot plate; *D* the base of the carriage, and *E* the cone. There are trunnions on the foresight ring, forming part of the jointed system. The structure is held in front by the recoil press *c*, and in rear by the elevating screw and nut moving in the box *d*. On firing, the gun recoils on the bars $B\ B^1$, controlled by the recoil press, and a strong spiral spring *e* forces it back into the firing position. The gun traverses by a lever *f* or by a hand-wheel on the pivot plate *C*. The mounting is prevented from jumping by a spring bolt. The arms, levers and pivot plate and the moving parts are cast steel. The cone is of gun-metal and the stand of plate iron; under it is a layer of wood to break the shock of discharge. The weight of the mounting is, upper part, 782.6 lbs.; lower part, 771.6 lbs. It has 15° arc of elevation and 15° of depression, and trains through the complete circle. It is worked by two men; one lays and fires, and one loads and acts as a substitute.

The ammunition is in the usual solid-drawn case; the 39-caliber gun fires common and steel armor-piercing shell, but not shrapnel and case. There is no special feature that makes it appear necessary to give a drawing of this ammunition. In the general system of working the breech, the Grüson rapid-firing gun resembles those of Nordenfelt and Hotchkiss. The rate of fire is higher than that of those guns in their competitive trials at Shoeburyness, but we have no recent results to compare with those of Herr Grüson.

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C.E.

(*Continued from page* 133.)

CHAPTER XXIII.

HOWE TRUSS BRIDGES.

In the preceding chapter the methods followed in designing and preparing the plates and bills of material for the series of Howe truss bridges were explained in detail, and in Plate 100 there was given the load diagram used in calculating the strains on the bridges. While the plans, strain-sheets and details accompanying the present chapter are complete, each in itself, a reference to Chapter XXII. may be of assistance to those who have not already seen it.

The plates given herewith are plans for three bridges of different spans. Plate 103 gives a bridge of 42 ft. span; Plate 104 one of 48 ft. span, and Plate 105 one of 52 ft. span. As heretofore noted, the number of feet span will be found on each plate in large figures, surrounded by a ring. The dimensions given on the plates, with those in the bills of material, will, it is believed, be sufficient to make of each a working plan which can be used without further preparation.

The accompanying bills of material will explain themselves; they have been carefully prepared, and all dimensions are given upon them. The patterns for castings and washers are indicated by letters, and the corresponding

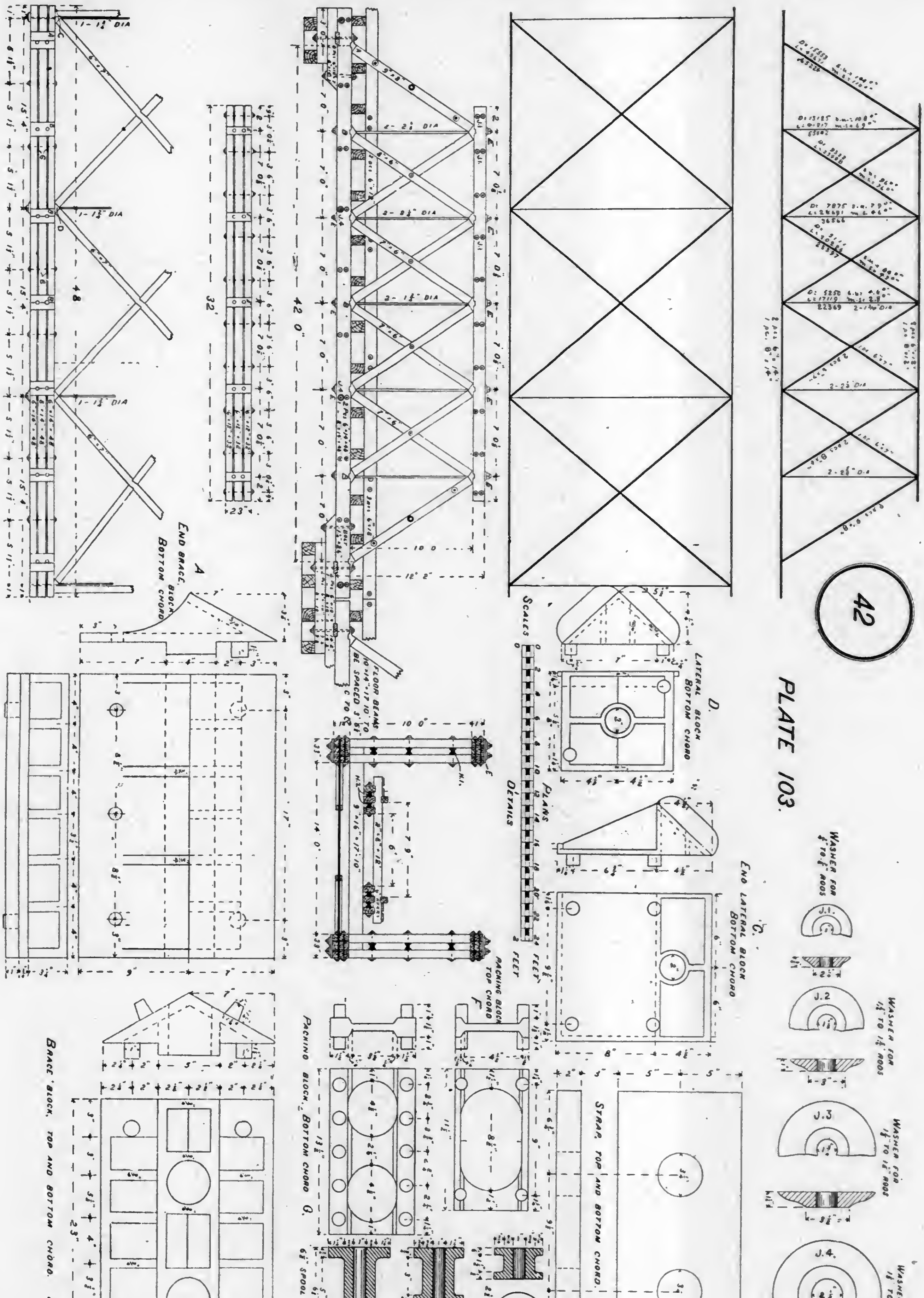


PLATE 103.
42
End Brace. Bottom Chord Block A
Lateral Block Bottom Chord D.
End Lateral Block Bottom Chord C.
Scales
Plans
Details
Feet
Packing Block Top Chord F
Packing Block, Bottom Chord G.
Brace Block, Top and Bottom Chord. B.
Strap, Top and Bottom Chord. E
Spool for End Braces H.1
Spool for Track Stringer H.2
Spool for Braces H.3
Washer for rods
J.1
J.2
J.3
J.4

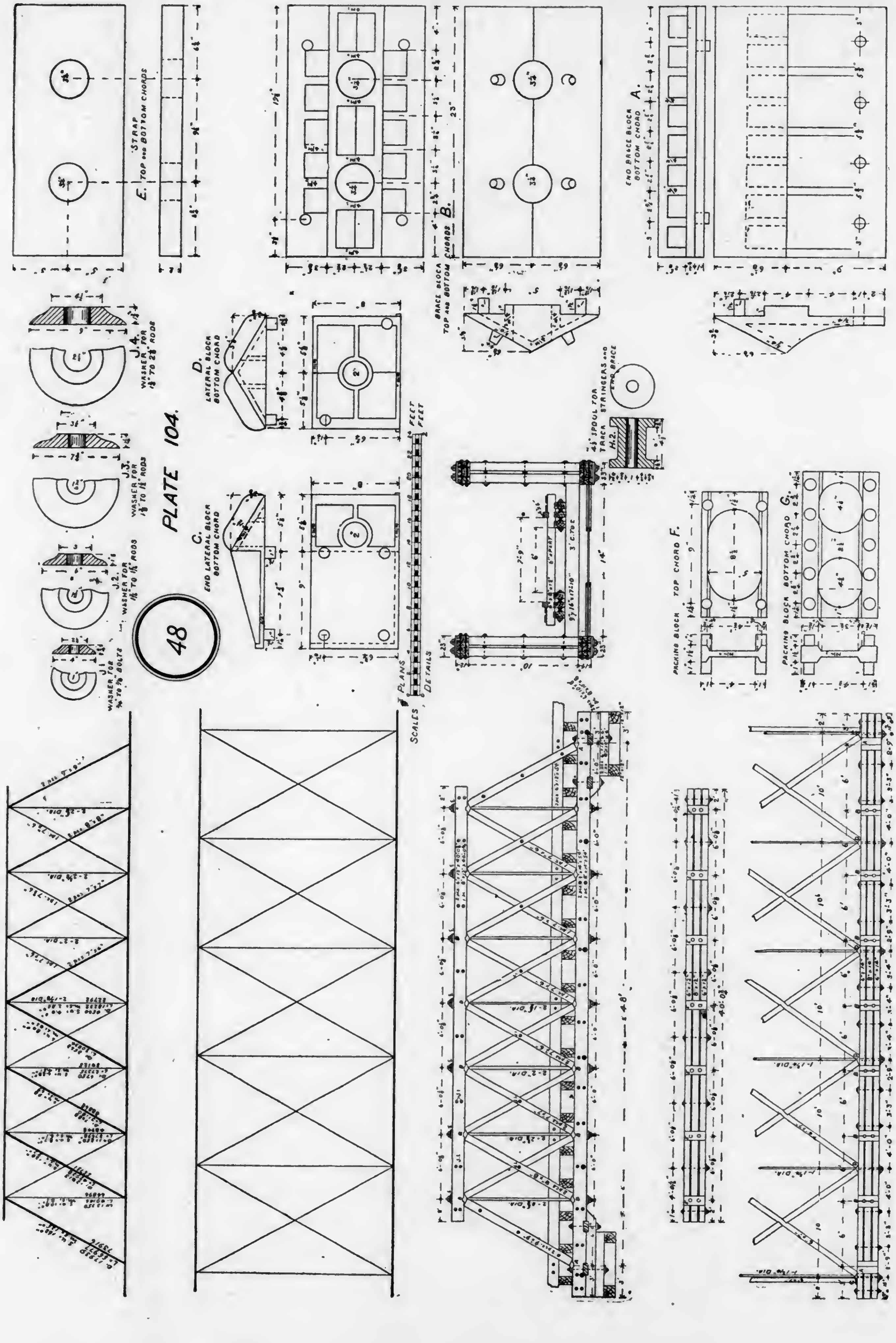


PLATE 104.
48
E. STRAP TOP AND BOTTOM CHORDS
B. BRACE BLOCK TOP AND BOTTOM CHORDS
A. END BRACE BLOCK BOTTOM CHORD
D. LATERAL BLOCK BOTTOM CHORD
C. END LATERAL BLOCK BOTTOM CHORD
TOP CHORD F. PACKING BLOCK
PACKING BLOCK BOTTOM CHORD G.
H.2. SPOOL FOR TRACK STRINGERS AND END BRACE
SCALES PLANS DETAILS FEET

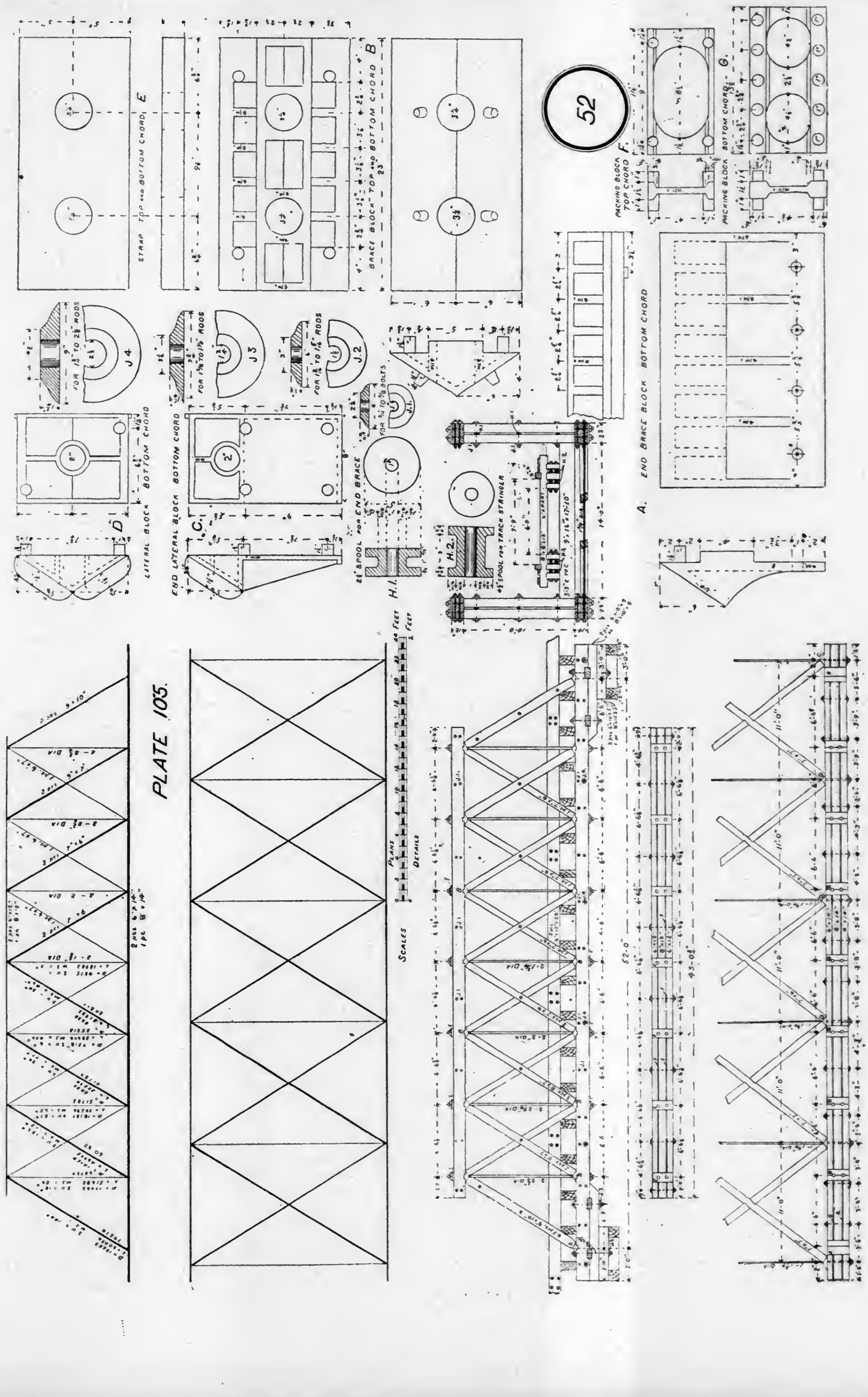


PLATE 105.
52
STRAP TOP AND BOTTOM CHORD
BRACE BLOCK TOP AND BOTTOM CHORD
END BRACE BLOCK BOTTOM CHORD
LATERAL BLOCK BOTTOM CHORD
END LATERAL BLOCK BOTTOM CHORD
PACKING BLOCK TOP CHORD
PACKING BLOCK BOTTOM CHORD
SPOOL FOR END BRACE
SPOOL FOR TRACK STRINGER
SCALES

letters will be found attached to the drawings on the plates.

No. 41. Bill of Material for Howe Truss Bridge, 42 Ft. Span. Plate 103.

Wood.

No. of Pieces.	Description.	Size.	Length.	Ft. B. M.	Kind of Wood.
4	Top Chord...	6 in. × 12 in.	32 ft. 0 in.	762	Yellow Pine.
2	" " ...	8 in. × 12 in.	32 ft. 0 in.	512	" "
4	Bottom Chord	6 in. × 14 in.	48 ft. 0 in.	1,344	" "
2	" "	8 in. × 14 in.	48 ft. 0 in.	896	" "
8	Main Braces..	9 in. × 8 in.	16 ft. 0 in.	768	" "
8	" "	8 in. × 6 in.	16 ft. 0 in.	512	" "
8	" "	7 in. × 6 in.	16 ft. 0 in.	448	" "
8	Counters... .	7 in. × 6 in.	16 ft. 0 in.	448	" "
6	Laterals......	6 in. × 7 in.	20 ft. 0 in.	420	" "
2	"	6 in. × 7 in.	14 ft. 0 in.	98	" "
8	Bolsters......	6 in. × 10 in.	7 ft. 0 in.	280	" "
4	"	8 in. × 10 in.	7 ft. 0 in.	190	" "
8	Bridge-seats..	6 in. × 10 in.	5 ft. 0 in.	200	" "
4	" " ..	8 in. × 10 in.	5 ft. 0 in.	134	" "
4	Sills..........	12 in. × 12 in.	18 ft. 0 in.	864	Spruce or Pine
14	Floor-beams..	9 in. × 16 in.	18 ft. 0 in.	3,024	" " "
6	Track String's	6 in. × 12 in.	48 ft. 0 in.	1,728	" " "
44	Ties..........	8 in. × 8 in.	12 ft. 0 in.	2,816	Oak.
2	Guard-rails...	6 in. × 6 in.	48 ft. 0 in.	288	Spruce or Pine
4	Planks.......	2 in. × 8 in.	48 ft. 0 in.	256	" " "
8	Blocks.... ...	2 in. × 8 in.	2 ft. 0 in.	22	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2⅝ in.	12 ft. 10 in.	12	Bolster-b'lts	1¼ in.	3 ft. 3 in.
8	"	2¼ in.	12 ft. 10 in.	14	Floor-bolts.	1¼ in.	4 ft. 4 in.
4	"	1¾ in.	12 ft. 10 in.	14	Tr. stringer.	¾ in.	2 ft. 6 in.
4	Laterals.	1¾ in.	18 ft. 6 in.	24	Tie-bolts.	¾ in.	2 ft. 6 in.
72	Chord-bolts.	¾ in.	2 ft. 0⅛ in.	14	Guard-b'lts.	¾ in.	1 ft. 3 in.
20	Brace-bolts.	¾ in.	2 ft. 0⅛ in.	24	Spikes.	⅝ in.	9 in.
12	Bolster-b'lts	1¼ in.	2 ft. 2 in.				

Washers, No. : 300 of pattern *J1* ; 76 of *J2* ; 8 of *J4*.

Castings.

Pieces : 4 of pattern *A* ; 20 of *B* ; 4 of *C* ; 4 of *D* ; 40 of *F* ; 40 of *G* ; 20 of *E* ; 12 of *H1* ; 20 of *H2* ; 8 of *H3*.

No. 42. Bill of Material for Howe Truss Bridge, 48 Ft. Span. Plate 104.

Wood.

No. of Pieces.	Description.	Size.	Length.	Ft. B. M.	Kind of Wood.
4	Top Chord....	6 in. × 12 in.	40 ft. 0¾ in.	760	Yellow Pine.
2	" "	8 in. × 12 in.	40 ft. 0¾ in.	640	" "
4	Bottom Chord	6 in. × 12 in.	54 ft. 0 in.	1,296	" "
2	" "	8 in. × 12 in.	54 ft. 0 in.	864	" "
8	Braces	9 in. × 9 in.	16 ft. 0 in.	864	" "
8	"	8 in. × 8 in.	16 ft. 0 in.	688	" "
8	"	7 in. × 7 in.	16 ft. 0 in.	528	" "
8	"	7 in. × 6 in.	16 ft. 0 in.	448	" "
12	Counters.....	7 in. × 6 in.	16 ft. 0 in.	672	" "
10	Laterals......	7 in. × 6 in.	17 ft. 0 in.	600	" "
2	"	7 in. × 6 in.	14 ft. 0 in.	98	" "
8	Bolsters......	6 in. × 10 in.	8 ft. 0 in.	320	" "
4	"	8 in. × 10 in.	8 ft. 0 in.	216	" "
8	Bridge-seats..	6 in. × 10 in.	6 ft. 0 in.	240	" "
4	" " ..	8 in. × 10 in.	6 ft. 0 in.	160	" "
4	Sills..........	12 in. × 12 in.	18 ft. 0 in.	864	Spruce or Pine
18	Floor-beams..	9 in. × 16 in.	18 ft. 0 in.	3,888	" " "
6	Stringers......	6 in. × 12 in.	54 ft. 0 in.	1,944	" " "
48	Ties..........	8 in. × 8 in.	12 ft. 0 in.	3,072	Oak.
2	Guards.......	6 in. × 6 in.	54 ft. 0 in.	324	Spruce or Pine
4	Planks........	2 in. × 8 in.	54 ft. 0 in.	288	" " "
8	Blocks........	2 in. × 8 in.	2 ft. 0 in.	24	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2⅝ in.	12 ft. 10 in.	12	Bolster bolts	1¼ in.	2 ft. 2 in.
8	"	2⅜ in.	12 ft. 10 in.	12	" "	1¼ in.	3 ft. 3 in.
8	"	2 in.	12 ft. 10 in.	18	Floor-bolts.	1¼ in.	4 ft. 4 in.
4	"	1⅝ in.	12 ft. 10 in.	32	String'rb'lts	¾ in.	2 ft. 6 in.
6	Laterals.	1¾ in.	18 ft. 6 in.	18	Tie-bolts.	¾ in.	2 ft. 6 in.
88	Chord-bolts.	¾ in.	2 ft. 0⅛ in.	18	Guard-bolts.	¾ in.	1 ft. 3 in.
24	Brace-bolts.	¾ in.	2 ft. 0⅛ in.	32	Spikes.	⅝ in.	9 in.

Washers, No. : 400 of pattern *J1* ; 84 of *J2* ; 12 of *J4*.

Castings.

Pieces : 4 of pattern *A* ; 28 of *B* ; 4 of *C* ; 8 of *D* ; 28 of *E* ; 32 of *F* ; 72 of *G* ; 32 of *H2*.

No. 43. Bill of Material for Howe Truss Bridge, 52 Ft. Span. Plate 105.

Wood.

No. of Pieces.	Description.	Size.	Length.	Ft. B. M.	Kind of Wood.
4	Top Chord....	6 in. × 12 in.	43 ft. 0¾ in.	1,056	Yellow Pine.
2	" "	8 in. × 12 in.	43 ft. 0¾ in.	704	" "
4	Bottom Chord	6 in. × 14 in.	58 ft. 0 in.	1,624	" "
2	" "	8 in. × 14 in.	58 ft. 0 in.	1,083	" "
8	Braces........	9 in. × 10 in.	16 ft. 0 in.	960	" "
8	"	9 in. × 7 in.	16 ft. 0 in.	672	" "
8	"	8 in. × 7 in.	16 ft. 0 in.	608	" "
8	"	7 in. × 6 in.	16 ft. 0 in.	448	" "
12	Counters.....	7 in. × 6 in.	16 ft. 0 in.	672	" "
10	Laterals.	7 in. × 6 in.	18 ft. 0 in.	630	" "
2	"	7 in. × 6 in.	14 ft. 0 in.	98	" "
8	Bolsters......	6 in. × 10 in.	9 ft. 0 in.	360	" "
4	"	8 in. × 10 in.	9 ft. 0 in.	240	" "
8	Bridge-seats..	6 in. × 10 in.	5 ft. 0 in.	200	" "
4	" "	8 in. × 10 in.	5 ft. 0 in.	134	" "
4	Sills..........	12 in. × 12 in.	18 ft. 0 in.	864	Spruce or Pine
18	Floor-beams..	9 in. × 16 in.	18 ft. 0 in.	3,888	" " "
6	Stringers.....	6 in. × 12 in.	58 ft. 0 in.	2,088	" " "
51	Ties..........	8 in. × 8 in.	12 ft. 0 in.	3,264	Oak.
2	Guards	6 in. × 6 in.	58 ft. 0 in.	348	Spruce or Pine
4	Planks........	2 in. × 8 in.	58 ft. 0 in.	312	" " "
8	Blocks........	2 in. × 8 in.	2 ft. 0 in.	22	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2¾ in.	12 ft. 10 in.	12	Bolster bolts	1¼ in.	2 ft. 6 in.
8	"	2⅜ in.	12 ft. 10 in.	12	" "	1¼ in.	3 ft. 3 in.
8	"	2 in.	12 ft. 10 in.	18	Floor-bolts.	1¼ in.	4 ft. 4 in.
4	"	1¾ in.	12 ft. 10 in.	32	Stringerb'lts	¾ in.	2 ft. 6 in.
6	Laterals.	1¾ in.	18 ft. 6 in.	18	Tie-bolts.	¾ in.	2 ft. 6 in.
84	Chord-bolts.	¾ in.	2 ft. 0⅛ in.	18	Guard-bolts.	¾ in.	1 ft. 3 in.
24	Brace-bolts.	¾ in.	2 ft. 0⅛ in.	32	Spikes.	⅝ in.	9 in.

Washers, No. : 400 of pattern *I1* ; 84 of *I2* ; 12 of *I4*.

Castings.

Pieces : 4 of pattern *A* ; 28 of *B* ; 4 of *C* ; 8 of *D* ; 28 of *E* ; 32 of *F* ; 64 of *G* ; 12 of *H1* ; 20 or 40 of *H2*.

In the plates following those published with this chapter there will be given some short spans used as deck bridges ; designs of sway-bracing which can be used when it is considered necessary ; and detail plans of different styles of guard-rails.

These guard-rails will be applicable to other forms of bridge than those given here ; and there can be no doubt that some device of this kind ought to be used on the approaches of all bridges, without any exception.

(TO BE CONTINUED.)

BOILERS WITH CORRUGATED FIRE-BOXES.

(Condensed from a paper read before the German Technical Railroad Union, by Herr H. Lentz Engineer, and published in *Glaser's Annalen.*)

IT is well known to every engineer who has charge of railroad motive power, that the repairs of the boiler are the most troublesome and costly and cause the greatest loss of time to locomotives. It may be said, indeed, that the boiler repairs overbalance all the other repairs, especially when the feed-water used is not of the very best quality.

Now it may also be said that most of the trouble in a locomotive boiler arises from the present shape of the fire-box, and from the extensive system of staying required in a rectangular fire-box of the ordinary pattern. The flat sides of both the outer and the inner fire-box and the crown-sheet of the inner fire-box will not withstand the steam pressure without a great number of stays, which not only require a great deal of work in building the boiler and constant watchfulness while it is in service, but also diminish the room, interfere with the free circulation of the water, and afford places upon which sediment can accumulate. In most European locomotives, moreover, where copper is used for fire-boxes, a further difficulty arises from the difference in the coefficient of expansion of the copper plates of the inner fire-box and the iron or steel plates of the outer shell. The strain caused by this unequal expansion is transmitted through stay-bolts which are necessarily very short, and are hence subject to unequal strains and frequently break. It is well known that the greater number of boiler explosions result from the failure of the stay-bolts and the giving way of the flat surfaces of the fire-boxes.

If we take, for instance, the standard freight locomotive of the Prussian State Railroads, a sectional sketch of which is shown in fig. 1, we find that there are in and around the fire-boxes over 800 stay-bolts and braces, the use of which could be avoided by a more rational method of construction.

Moreover, as noted above, on account of the narrow water space between the inside and outside fire-box, and on acccount of the rapid generation of steam and agitation of the water which go on in that place, there is a constant deposit of sediment at the many resting points offered for it by these stays, and the resulting incrustations are very difficult to remove. This part of the boiler, therefore, requires a great deal of repair and of very difficult repair where the water used is not of the very best quality. In one case which came under the writer's observation on an Italian road, the eight-wheel freight engines used, under the most favorable circumstances, have to be supplied with new fire-boxes at the end of three years, and on one part of the road, where the water used is of very bad quality, a new fire-box, braces and stay-bolts are needed every year. In this way not only is the cost of repairs very high, but the company has necessarily a greater amount of capital invested in locomotives, since provision must be made to fill the places of those engines which are laid up for repairs.

I wish in the present paper to present a method of construction by which many of these evils referred to may be avoided.

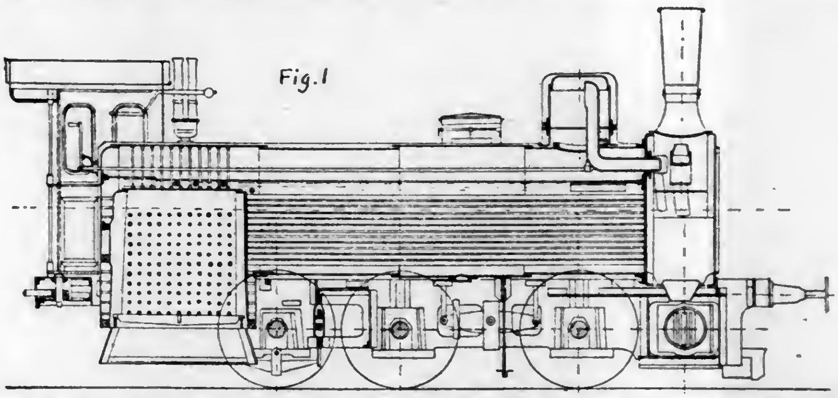


Fig. 1

Cylindrical fire-boxes were used from 15 to 20 years ago by Kaselowsky, and there are several later instances of their use in locomotives. In America they have been used in the Strong locomotive, in that case a double fire-box being provided. The use of the cylindrical fire-boxes in marine boilers and in stationary boilers is also well known. The resistance of the corrugated cylindrical tube to pressure is so high that in those of the size required for a locomotive fire-box almost any attainable pressure would be admissible.

Some time ago Herr Pohlmeyer built in Dortmund* a locomotive with a fire-box of this kind, and this engine has now been in use for two years with very favorable results.

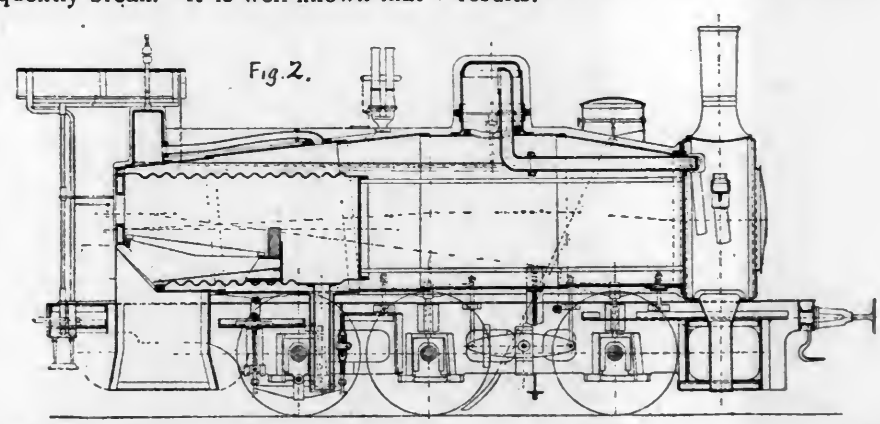


Fig. 2.

In order to make clear this method of boiler construction, I have shown herewith in fig. 1 a section of the standard freight locomotive of the Prussian State Railroads as now built, and in fig. 2 a section of the same engine with a fire-box consisting of a corrugated tube. It will be seen that not only is there an absence of all the flat surfaces shown in fig. 1, and of the great number of stay-bolts required in that engine, but the greatest steam room is provided in the center of the boiler. The smallest diameter is at the rear end, which has the advantage of giving more room in the cab, and while the boiler is higher in the center, it does not reach such a height as to interfere

* This engine, built by Herr Pohlmeyer, was described and illustrated in the RAILROAD AND ENGINEERING JOURNAL for June, 1889, page 272.

with the outlook of the engineer. The section of the boiler at the center is oval and not circular, but this form, it is believed, will present as great a resistance to pressure as the entirely circular boiler. In other words, the boiler is

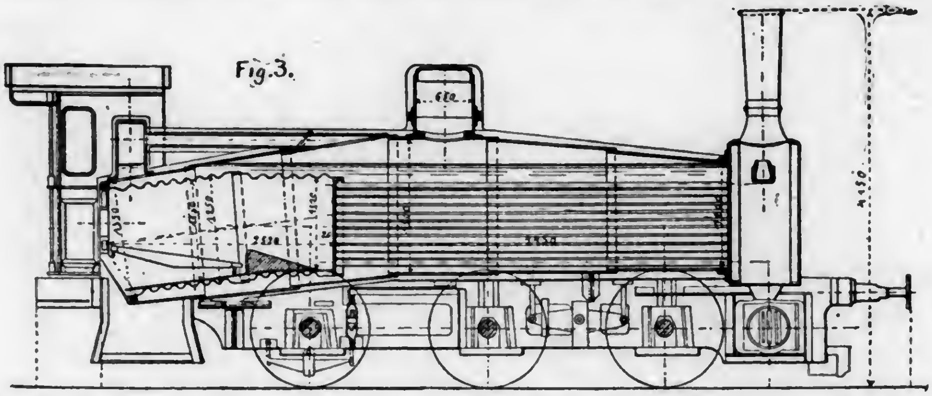


Fig. 3.

somewhat like what is called in America a wagon-top form, but the wagon-top is at the center of the boiler, and not at the rear end.

The engine shown in fig. 2 has the same wheel-base and

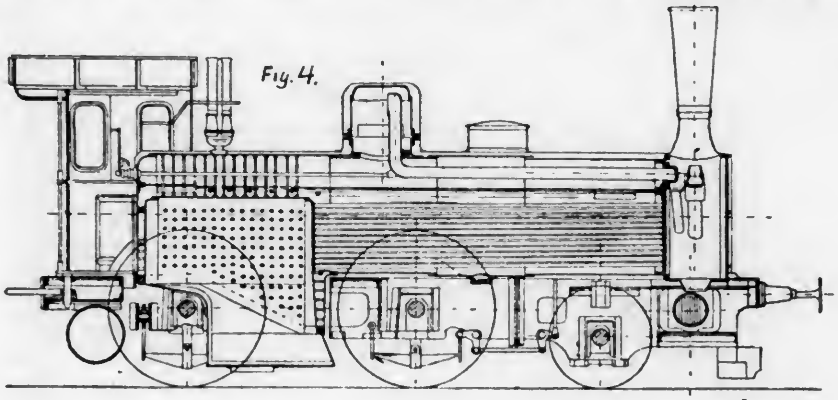


Fig. 4.

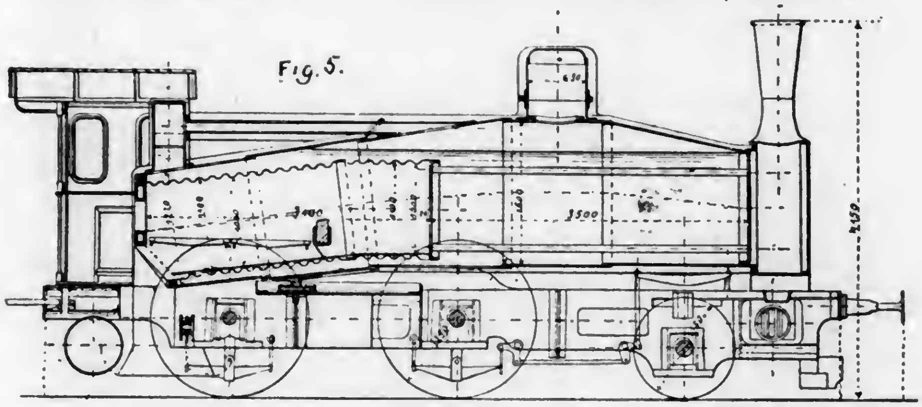


Fig. 5.

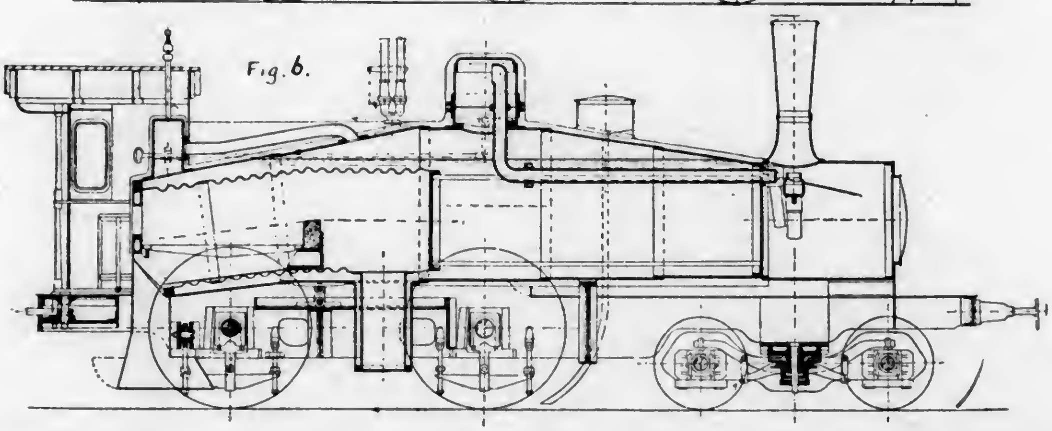


Fig. 6.

the same arrangement in all respects as the standard engine in fig. 1, the only change being in the substitution of the new boiler. It may be noted, however, that the use of the cylindrical boiler would permit in an engine of this pattern a very much better arrangement of the axles, giving a longer wheel-base, since the rear axle can be carried as far back under the fire-box as may be desired to proportion the engine properly. With an outside-cylinder engine also, the boiler can, if desired, be set lower than with the ordinary fire-boxes. The general arrangement proposed is shown sufficiently well in these sectional sketches, and a comparison of figs. 1, 2 and 3 will show the advantages that may be gained. In both the boilers shown in figs. 2 and 3, in order to permit of a free circulation a small dome is placed on the back end, which is connected with the central part of the boiler by a pipe.

(It may be noted that this last device proposed by Herr Lentz seems to add a complication to the construction of the boiler, which is not altogether desirable, and which could be easily avoided.)

The total number of stay-bolts and stays which can be dispensed with by the use of the cylindrical fire-boxes in the locomotives shown is 445.

It may be objected that the lower part of the fire-box is closed and is curved. It is easy to provide a flat surface by a plate placed under the grate, as shown in fig. 2. Arrangements can also be made, as shown in figs. 2 and 3, for the removal of the ashes. A discharge-pipe for the ashes carried over the fire-bridge can be provided, as shown in fig. 2, while, at the same time, the outer casing will serve as a receptacle for sediment, or mud-drum. The boiler shown in fig. 2 has been so designed that it can be substituted for the standard boiler without any change in the engine, while the total heating surface is the same; at the same time the total weight of the boiler is less and the weight upon the axles will be much more evenly distributed, fig. 2 being free from much of the overhanging weight thrown upon the rear axle in fig. 1.

Where this arrangement is applied to a passenger engine, there is a further advantage that not only can the axles be much better arranged, but there will be room given under the boiler for cross-bracing of the frames, which in a quick-running machine is a very considerable advantage. In fig. 4 there is shown a section of the standard passenger locomotive on the Prussian State Railroads, which has four coupled driving-wheels, and here the inconvenience caused by the necessity of putting the rear axle under the fire-box is very well known. Fig. 5 shows the same locomotive having a boiler with cylindrical fire-box substituted for the ordinary boiler shown in fig. 4. In this case there are 450 stay-bolts which can be dispensed with by the use of the cylindrical fire-box, while the somewhat awkward construction of the fire-box required in the first case is entirely dispensed with. The boiler shown in fig. 4 is of the same general construction as in figs. 2 and 3, that is with an oval section in the center.

Fig. 6 shows a proposed improvement of this passenger engine intended for use on fast trains. In this case the driving-wheel base is somewhat longer, and a four-wheel truck is substituted for the single pair of leading wheels in figs. 4 and 5. It is believed that the experience of English and American Railroads has shown this construction to be much the best for a fast-running locomotive. In fig. 6 also the length of the boiler is somewhat increased. Herr Lentz also shows a very similar arrangement for a four-wheel switching engine or for a four-wheel light passenger engine, a type which is much used on German railroads for local service, and shows the peculiar advantage gained in this case in the longer wheel-base and the absence of that overhanging weight, which is always a great objection in the use of four-wheel locomotives.

In fig. 7 there is shown an eight-wheel freight engine of the standard pattern in use on the Gothard Railroad. This engine is of a type which is frequently employed for heavy freight service on the Austrian, Russian and Italian railroads, and for this pattern—which is closely allied to the consolidation engine in use in this country—the tubular fire-box is believed to offer many advantages. Not only in the engine shown in fig. 7 is there a great overhanging weight, but, in order to give room for all the wheels and to keep the fire-box clear of the axles as much as possible, it is necessary to make a very long boiler. By the use of the cylindrical fire-box, as shown in fig. 8, the length of the boiler can be diminished, the weight upon the driving-wheels much better adjusted, and some 560 stay-bolts can be dispensed with. The same advantage is also presented here as with the passenger engine, and that is that the frames can be braced together in a very much better fashion. The boiler shown in fig. 8 is of the same type as that presented by Herr Lentz in the other cases. All of these advantages are strongly insisted upon by the writer.

Fig. 7.

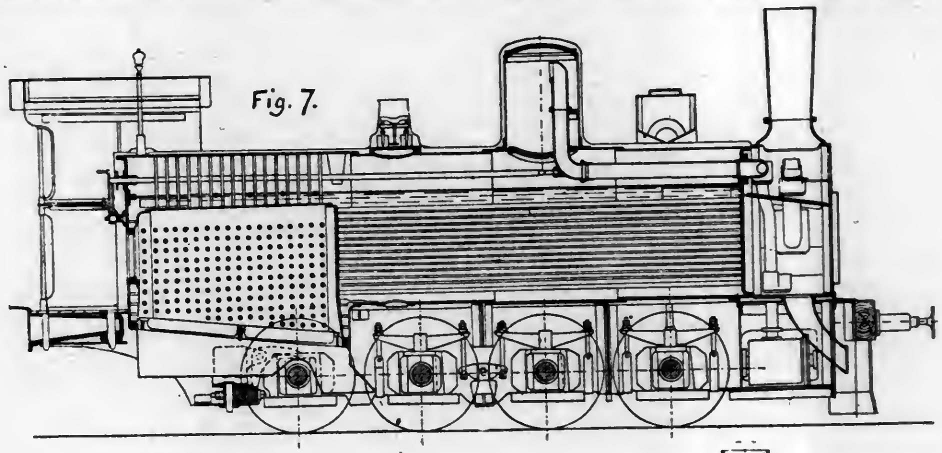
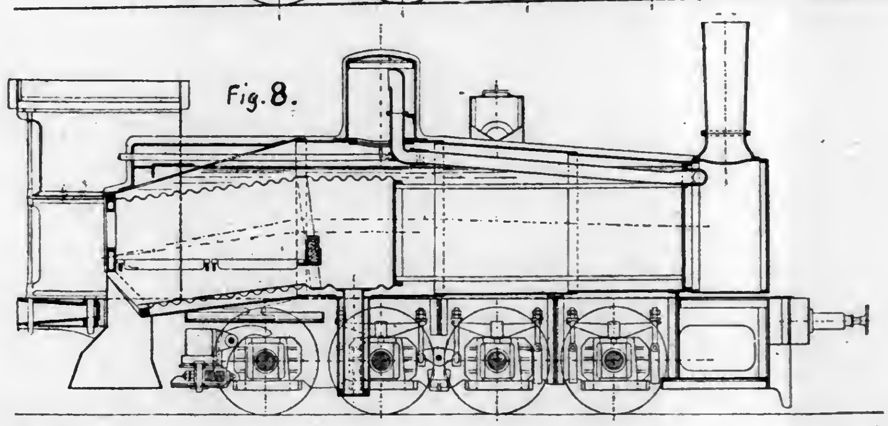


Fig. 8.



The cylindrical fire-boxes can be used both with outside cylinders or with inside cylinders and connections, to which some continental roads still adhere, although it may be said that the outside cylinder is much more common in other European countries than in England or France. In either case the advantage of the better arrangement of weight on the wheels can be obtained.

In conclusion, Herr Lentz presents the following claims for the advantages to be gained by the adoption of the cylindrical fire-box:

"1. The first cost of the engine would be lower by an amount varying according to the size of the engine, but given for an average German engine at from 4,000 to 5,000 marks (from $1,000 to $1,250).

"2. The cost of repairs and the time lost in repairs will

be very much reduced, and consequently the locomotives can be better utilized and the total amount and cost of the motive power diminished.

"3. Owing to the greater strength of the cylindrical fire-box and its greater resistance to pressure, the working pressure carried can be increased considerably, and greater advantage will be offered for the use of compound locomotives.

"4. Better consumption of the fuel, will be secured by the greater ease with which the grates can be cleaned and by the use of the combustion chamber, thus effecting a saving of fuel.

"5. Economy in fuel can also be secured from the fact that the fire-box shell remains clear of incrustation, and that the boiler can be much more easily washed out and sediment prevented.

"6. Periodical examinations of the boiler, which in the ordinary construction are required in order to see that no stay-bolts or stays are broken, will not be needed frequently ; but it will only be necessary to examine the fire-box shell and rings at longer intervals.

"7. By the adoption of the circular form of fire-box it is possible to obtain a much better, more useful and more economical force of locomotives, and so to effect a considerable saving in the management of the motive power department."

Not all of Herr Lentz's claims will be admitted by engineers generally, and he seems to have over-estimated the saving in first cost, but there is little doubt that the form of boiler which he describes presents many advantages which are worth considering. It is understood that the corrugated cylindrical fire-box—some examples of which are already in trial in Germany, and one of which was described in the JOURNAL for June, 1889, page 272—is to be given a thorough trial on some of the German railroads, and the results of this trial will be looked for with interest.

THE DEVELOPMENT OF ARMOR.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

(*Continued from page* 104.)

IX.—FOREIGN ARMOR-CLAD FLEETS.

In the matter of national defense armor-clad fleets have become so important an adjunct, that there is scarcely a civilized power possessing a single seaport, but what has made a beginning in iron-clad construction.

England naturally leads the list with an armor-clad fleet, built and building, of 81 ships, including those in colonial service, and the 8 battle-ships just begun, as well as a number of obsolete craft of little practical value. Of this number more than one-half, or 45, are battle-ships. France follows with 61 names of all descriptions upon her navy list, 24 of which are battle-ships. Although Germany is credited with 30 armored ships of different kinds, a very large proportion of these are of obsolete types, of iron, and with comparatively thin iron armor. A single steel 5,200-ton barbette ship, with a maximum thickness of 13 in. of compound armor, is the only modern type of iron-clad upon her list.

Of the 41 armored ships of Russia, more than one-half are coast-service vessels, or armored gunboats of small tonnage, but among the remainder she has 3 steel barbette battle-ships of the first class, of the type of the *Catherine II.* These vessels have something over 10,000 tons displacement ; a water-line belt of 16-in. armor, and a central citadel enclosing three barbette towers, and protected with 14-in. armor.

Of Italy's 21 armor-clads, completed or on the stocks, 10 are first-class battle-ships, with an aggregate tonnage of more than 123,000 tons. Austria has an iron-clad fleet of 14 ships. All are provided with a water-line belt, and all but two are of old types, with from 5 to 9 in. of plating. Her most formidable fighting representative is a 7,000-ton barbette ship of steel, with 12 and 11 in. armor on belt and barbette respectively. The Netherlands have a fleet of 23 armored ships, all of old type and of iron. All but two of this number are coast-service vessels or armored gunboats, and none have a greater thickness of armor than 11½ in. of iron.

Sweden has 16 iron-clads on her navy list. These are all coast-defense vessels, except two, are of iron, and of obsolete types. The two exceptions are 3,000-ton turret ships of steel, and have a maximum thickness of armor of 11½ in. Denmark has 12 protected ships of all kinds. The larger part have iron-armor of from 2½ to 8 in. She is building a 2,400-ton torpedo-ship, with 4 in. deck and 8 in. battery armor of steel. Norway has but 4 iron-clads—all of old type.

Turkey has a fleet of 19 iron-clads. None of these have been launched since 1875. The most powerful is a 9,000-ton ship, with a maximum thickness of 12 in. iron-armor. The greater part are thinly armored. Of other European powers, Greece has 4 iron-clads and Portugal 1, while Roumania brings up the rear with a single protected cruiser.

Of the South American Republics, Brazil has 12 iron-clads, including 3 river monitors, with 4½ in. of armor. The remainder are mostly turret vessels, with plating of about the same thickness. The older types have iron, the newer compound armor. The best representative of Brazil's navy is a 5,700-ton steel turret ship, with 11 in. compound armor. Chili has 3 thinly armored iron-clads of old design ; besides these, a new 6,900-ton steel barbette ship is being built in France, to be provided with 12-in. armor. Of China's 4 iron-clads, 3 are of steel, of recent construction, built in Europe, and provided with from 8 to 14 in. of compound armor. Two of these have a displacement of about 7,500 tons. Japan has 7 armored vessels on her list, all thinly protected, and but one of recent design.

In the three decades, beginning with 1860, during which iron-clad shipbuilding has been carried on, it is impossible to say how many armor-clad vessels of all descriptions have been built. Of the 343 now reported as in service, or under construction, by all the maritime powers, the United States excepted, 111 were built during the decade of 1860–70, 107 during that of 1870–80, and 115 during that just closed. If we add to this the very considerable number that have been condemned and dropped, principally those constructed in the sixties, we see that during the first decade of the series by far the greater number were built. If considered in relation to tonnage, the decade just passed will greatly surpass either of the others.

X.—THE FINAL TEST.

The final value of any variety of armor-plate, or of any system of its application, can only be determined by the crucial test of battle. Experiments at the practice-butts can approach but remotely the actual conditions of battle. Armor-plate of any kind upon a vessel under way, presenting each instant a constantly-changing target, both as regards angle and distance, enveloped in smoke and uncertain in its outlines, and upon a yielding platform, will behave in an entirely different way from the same quality and thickness of metal placed against a rigid backing and fired at with all the care possible to long preparation. Added to this, the personal equation of the man behind the gun must be considered ; he may be cool and collected, but more likely excitement, or fear, or both, will greatly reduce his efficiency. All of these conditions will favor the armor-plate, and we are safe in giving it a considerably increased value over that demonstrated on the trial ground.

Outside of the United States, during the three decades of iron-clad shipbuilding, there have been few opportunities of bringing armor to this test. Even the lessons learned during our Civil War, of which mention will be made hereafter, or the few battle-tests that have since occurred, can now have but a general value, since not only the nature of the armor-plate itself, but the manner of its distribution, as well as the character and power of the projectiles brought against it, have all greatly changed within a very recent period.

The battle of Lissa, in 1866, gave the first opportunity of testing iron-clad against iron-clad. The Austrians brought into action 7 iron-clad frigates, in addition to

a fleet of 14 wooden ships. Against these the Italians mustered 8 iron-clads, and a double-turreted sea-going monitor. The Austrian ships had complete armor protection along the water-line and for the main-deck battery, of from 2½ to 5 in. in thickness. The Italian ships had likewise water-line protection, but 3 of them were poorly protected at the ends. The armor varied from 3 to 4⅜ in. in thickness. The armament of the 7 Austrian iron-clads aggregated 173 guns, 74 of which were 6-in. breech-loading rifled cast-iron Wahrendorf guns, the others 48-pounder smooth-bores. The Italians brought something over 200 guns into action, all rifled and ranging in caliber from the 6½-in. Cavalli breech-loader to the 9-in. Armstrong muzzle-loader.

Early in the action the steering-gear of the Italian iron-clad *Re d'Italia* was shot away, and while in this disabled condition she was rammed and sunk by the *Ferdinand Max*, the Austrian flagship. The *Palestro*, another of the imperfectly protected Italian ships, was set on fire, and subsequently blew up. The Italians lost two ships and nearly 700 men killed and wounded; the Austrian loss was less than 150.

The armor of the Italian ships is said to have been hard and brittle, and was evidently inferior to that of the Austrians. The Austrian report says that their armor behaved remarkably well. The 9-in. rifled shot from the Armstrong guns failed to get through even 4½ in. of plate. It also says that the great loss in killed and wounded on the Italian ships was due in a great measure to the fact that the Austrian projectiles struck the edges of the plating near the ports, sending showers of fragments from the brittle metal among the gunners.

In 1868, during the war between Brazil and Paraguay, a Brazilian single-turreted river monitor, armored with 4½-in. side and 6-in. turret armor, in solid plates, attacked at short range Paraguayan batteries armed with 32-pounder Whitworth rifles, and 68 and 120-pounder smooth-bores. The monitor is reported to have been struck some 200 times. Besides being badly damaged about the turret, 12 shot penetrated the side-armor, and two found their way through that of the turret. Considering the shortness of the range and the incessant pounding it received, the armor-plate may be said to have behaved well, although hardly equal to the work imposed upon it.

At Cartagena, Spain, in October, 1873, a duel took place between the insurgent iron-clad *Numancia* and the Spanish ship *Vittoria*, both of something over 7,000 tons. The former had 5-in. armor, and was armed with 7 and 10-in. Armstrong guns; the latter, 5½ in. armor and an armament of 8 and 9-in. Armstrongs. During the engagement the armor of the *Numancia* was struck 14, and that of the *Vittoria* 8 times by heavy shot, but the projectiles failed to penetrate, and no great damage was done.

In the action between the turreted iron-clad *Huascar* and the unarmored cruisers *Shah* and *Amythest* off the Peruvian coast, in 1877, the 64-pounder shell of the English ships were found useless against the thinnest armor-plate of the *Huascar*. The *Huascar* had 4½ in. of solid armor on the sides amidships, tapering to 2 in. at the bow and stern, and 5½ in. solid plates on her turret, all well backed with teak.

Two years later the *Huascar* had a fight with the Chilian iron-clad corvettes, *Encalada* and *Cochrane*. These had a water-line armor-belt of from 4½ to 9 in. in thickness, and battery armor of from 6 to 8 in. The armament consisted of six 9-in. muzzle-loading Armstrong rifles. The *Huascar* mounted two 10-in. guns of the same pattern in her turret.

The fight lasted an hour and a half, at the end of which time the *Huascar* had lost her four senior officers, and 76 out of a crew of 200 men, when she surrendered. During the fight the armor of the *Huascar* was struck 20 times by heavy shot, 10 of which perforated the armor, while five glanced off. Many shots took effect on the unarmored parts, principally the stern. The 5½-in. turret armor was pierced twice, the 4-in. armor once, the 3-in. armor four times, the 2½-in. armor twice, and the 2-in. armor once. The projectiles which perforated the turret armor and partially disabled the guns were fired by the *Cochrane* at a range of about 12 yards.

The gunnery on the *Huascar* was poor. The *Encalada* received no injury. The *Cochrane* was struck twice. A 10-in. Palliser chilled shell, fired at a range of 600 yards, struck her armor at an angle, indenting it to a depth of 3 in.; another, striking on the quarter above the water-line armor, penetrated and burst, wounding 10 men. In addition to the loss of more than a third of her strength, the *Huascar* was three times disabled by the enemy's fire, many times set on fire, her turret was jammed, and one of her turret guns disabled. Although her armor is said to have been of very fine quality, it was of insufficient thickness to cope with the 9-in. projectiles of her adversaries, delivered at close range. One writer, speaking of this, says: "The armor in this case was only a great disadvantage to her. It served to explode the enemy's projectiles; . . . the backing and inner skin only served to increase the number of fragments, which were driven into the interior of the vessel with deadly effect. . . . The explosion of each shell—and each shell which pierced the armor exploded—set the ship on fire in a new place." It should be added that the armor-plate was of soft wrought-iron of English manufacture. Had it been of any of the hard-faced modern varieties, it is safe to say that not a single hollow projectile would have gotten through.

The bombardment of Alexandria by the English fleet, in July, 1882, affords the latest example of the behavior of armor-plate under fire. Although the Egyptian fortifications were largely of a very inferior quality of masonry, the guns mounted therein were many of them of the best type of English manufacture, provided with an abundance of the best ammunition: 27 Armstrong muzzle-loading rifles figure in the list, together with smooth-bores and mortars enough to bring the total armament up to over 200 guns. The English brought against these seven iron-clads of various tonnage, from the *Penelope* of about 5,000 tons to the 12,000-ton *Inflexible*, with armor ranging from the 6-in. plating of the former to the 24-in. of the latter. The Egyptians stood to their guns manfully, and only after a 10 hours' bombardment, at distances from 700 to 1,500 yards, and not until many of their guns were disabled and tons of their rotten masonry had been knocked about their ears, were the batteries silenced.

On the *Alexandra* the armor was struck a number of times without inflicting any injury, but above the armor-plating 24 shot and shell found their way, causing much damage to cabins, lower deck, etc. Upon the *Invincible*, *Sultan*, and *Superb*, the blows upon the armor-plating in no case did more than indent the metal, and, in one or two instances, slightly start it from its backing, but their upper works and top-hamper suffered considerably. The fighting qualities of the ships were, however, in no way injured.

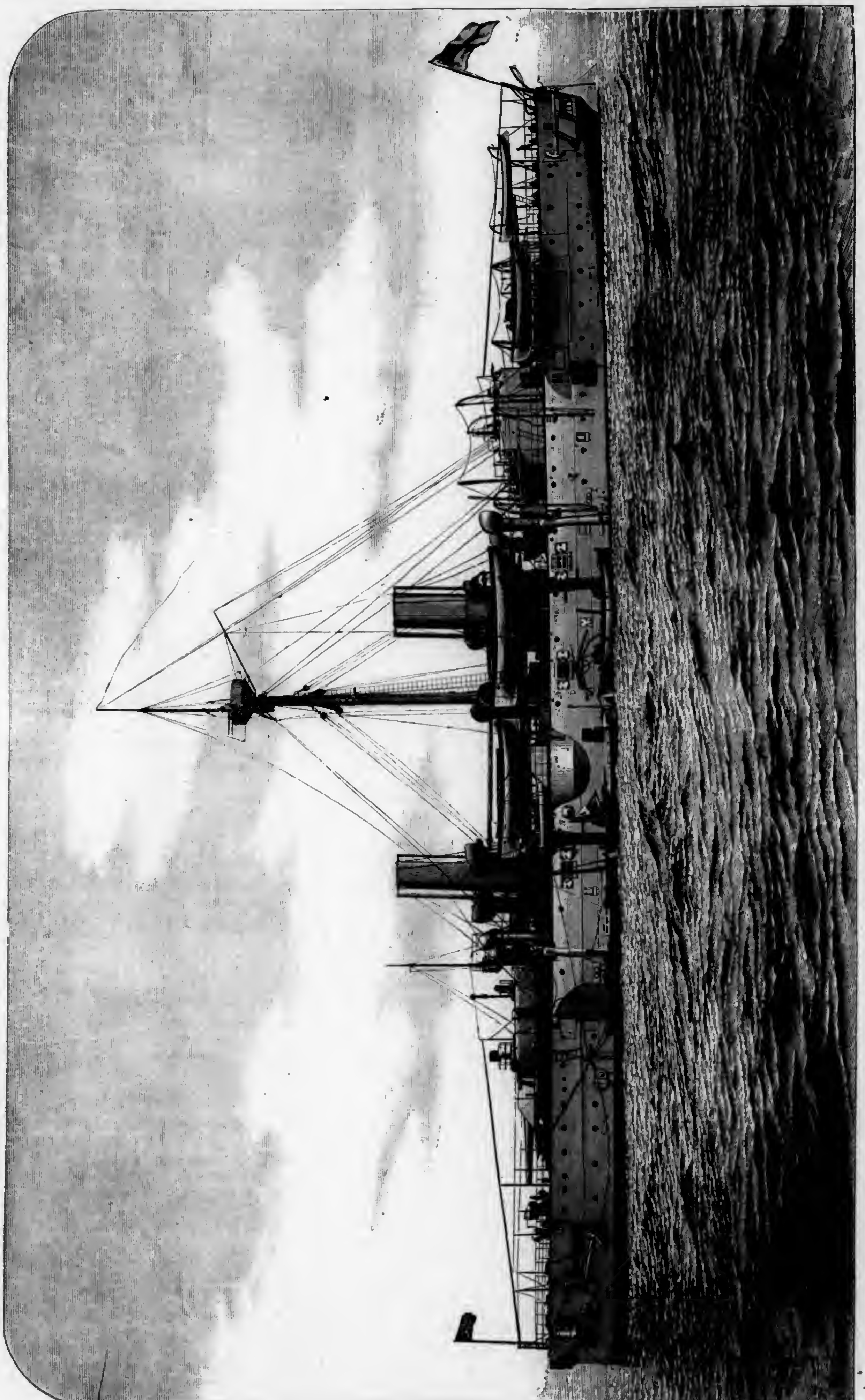
The report upon the injuries suffered by the *Inflexible* was not made public. Besides considerable damage to her superstructure and upper works, she is said to have been pierced under water, probably below the armor-belt, which necessitated her subsequent docking. The losses were insignificant—6 men killed and 27 wounded.

(TO BE CONTINUED.)

AN ENGLISH ARMORED CRUISER.

THE accompanying illustrations—from the London *Engineer*—show the *Impérieuse* of the English Navy. The large engraving is taken from a photograph of the vessel while at anchor; of the smaller cuts, fig. 1 is a side view, fig. 2 a deck plan, fig. 3 a midship section, and fig. 4 a section outside of the armor-belt.

The *Impérieuse* and her sister ship, the *Warspite*, which are classified as armored cruisers of the first class, represent a type of war vessel totally distinct from the citadel battle-ships which preceded their introduction into the English Navy, or the barbette *Admirals* and turret battle-ships which followed them. They are peculiar in having four distinct protected positions for heavy guns, separated from one another, and unconnected by means of vertical armor or other contrivance. Each of these positions is provided with an elevated barbette, sheathed with 8-in. composite armor, and mounting a single 24-ton, 9-in.



FIRST-CLASS ARMORED CRUISER "IMPÉRIEUSE," FOR THE BRITISH NAVY.

breech-loading steel gun, possessing a very considerable arc of training. At a lower level is placed a large number of guns of smaller caliber—6-in. steel breech-loaders—sheltered to some extent from the fire of the heavy guns. This arrangement has been adopted to a great extent from that followed by the French in the *Admiral Duperré*, the *Magenta* class, etc. It has its advantages in the division of the heavy-gun positions, so that it would be impossible to wreck them all simultaneously by a single adroitly-directed shot, as might take place in the central citadel battle-ships; but it is faulty, in that no armored connection exists between these positions, either for the secure transport of ammunition or the protection of gun detachments and 140 ft. long. It was to have been 3 ft. 3 in. above and 4 ft. 9 in. below water-line, but the alterations made during construction of the vessel made a difference in her trim, and it was found, when completed, that the lower line of her belt was 6 ft. 7½ in. below water-level, while the upper one was only 1 ft. 4½ in. above. She has, however, a steel armored deck at the top of the belt which would prevent projectiles penetrating into the engines, boilers, or magazines, even if they succeeded in getting through the sides of the *Impérieuse* when she heeled over toward her enemies. But it cannot be denied that the armored belt was never intended to be placed so low down, and the weakness of a design, which was so ill provided

FIG 1.

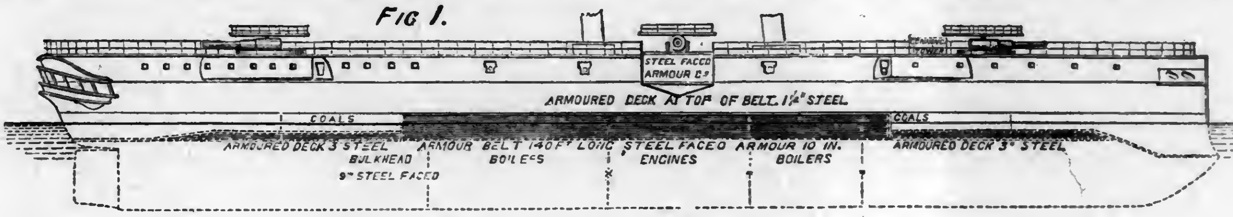
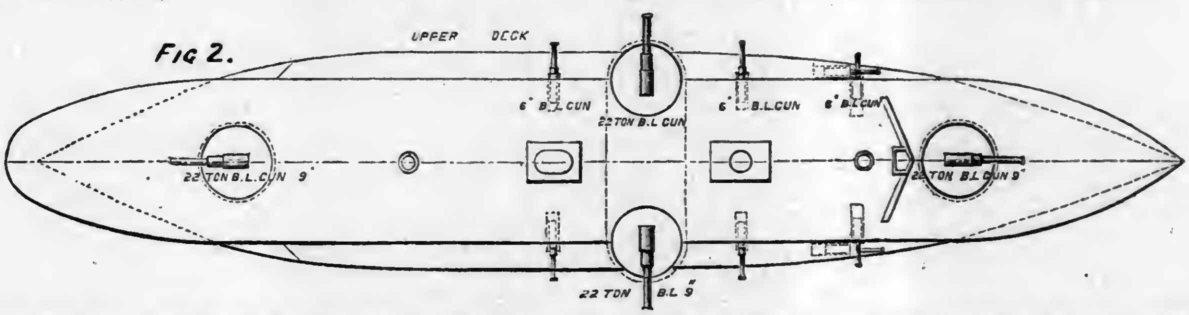


FIG 2.



passing to and fro. We must not omit to mention, however, that in it the first practicable arrangement is found for the auxiliary armament, the lesser batteries being at a lower level than the others, and thus the whole of the guns are capable of being worked independently in the heat of action, without any danger of their several lines of fire fouling one another. To provide a safe and sufficient distance between the guns of the auxiliary armament has been one of the most troublesome problems that Mr. W. H. White had to solve in the designs for the new battle-ships now in course of construction.

The *Impérieuse* is a twin-screw steel vessel, sheathed with wood, and coppered for tropical service. Her displacement is 8,400 tons, length, 315 ft., and beam, 62 ft.

FIG 3.

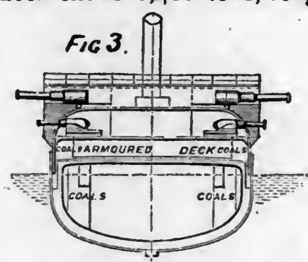
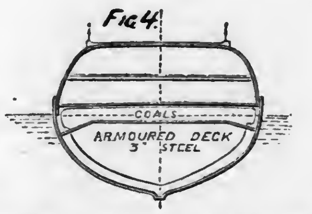


FIG 4.



She was completed at Portsmouth in 1886. Her engines are of the triple-expansion type, by Maudslay & Company, and of 10,000 H.P. She was designed to carry 400 tons of coal at her normal draft, with power to stow 900 tons when required; but it was subsequently found possible to stow as much as 1,130 tons. With this she could steam 7,000 knots at a 10-knot speed. But this extra coal, and her altered weights, would immerse her nearly 2 ft. below the water-line as designed, which gave her originally an extreme draft of 25 ft. 5 in. At present her draft is recorded as 27 ft. 4 in. This is, of course, with all weights on board. The removal of the masts and sails, she having been at first brig-rigged, and the substitution of a single fighting mast for the others, made a difference of 3 in. only in her draft, 100 tons weight being saved by this contrivance. A full speed, under forced draft, of 16¾ knots, was obtained at trial, this being three-quarters of a knot more than was anticipated by the original designers. With a smaller quantity of coal stowed she would rise about 1 ft. The *Impérieuse* has an armored belt 8 ft. wide, 10 in. thick, with a margin of buoyancy against possible alterations in trim during construction, is only too apparent. Fortunately the "Board margin," as it is called, which is to be considered in all future designs, will give ample scope for any fresh ideas which may crop up during the growth of vessels from their keels to completion. There are armored bulkheads of compound plate 9 in. thick at both ends of the belt, and from the base of these the steel armored deck extends to stem and stern; all the vitals are below the steel deck. The armament of the *Impérieuse* consists of four 9.2-in. 24-ton guns, six 6-in. 5-ton guns, 10 Nordenfelt guns, three torpedo-ports, and four 6-pounder quick-firing guns. The heavy guns are protected by steel shields upon the summit of the barbettes, behind which the gun detachments are partially sheltered. The position of the guns, auxiliary battery, belt, etc., can be best seen by a reference to the cuts which give the whole in detail—elevation, plan, and sections.

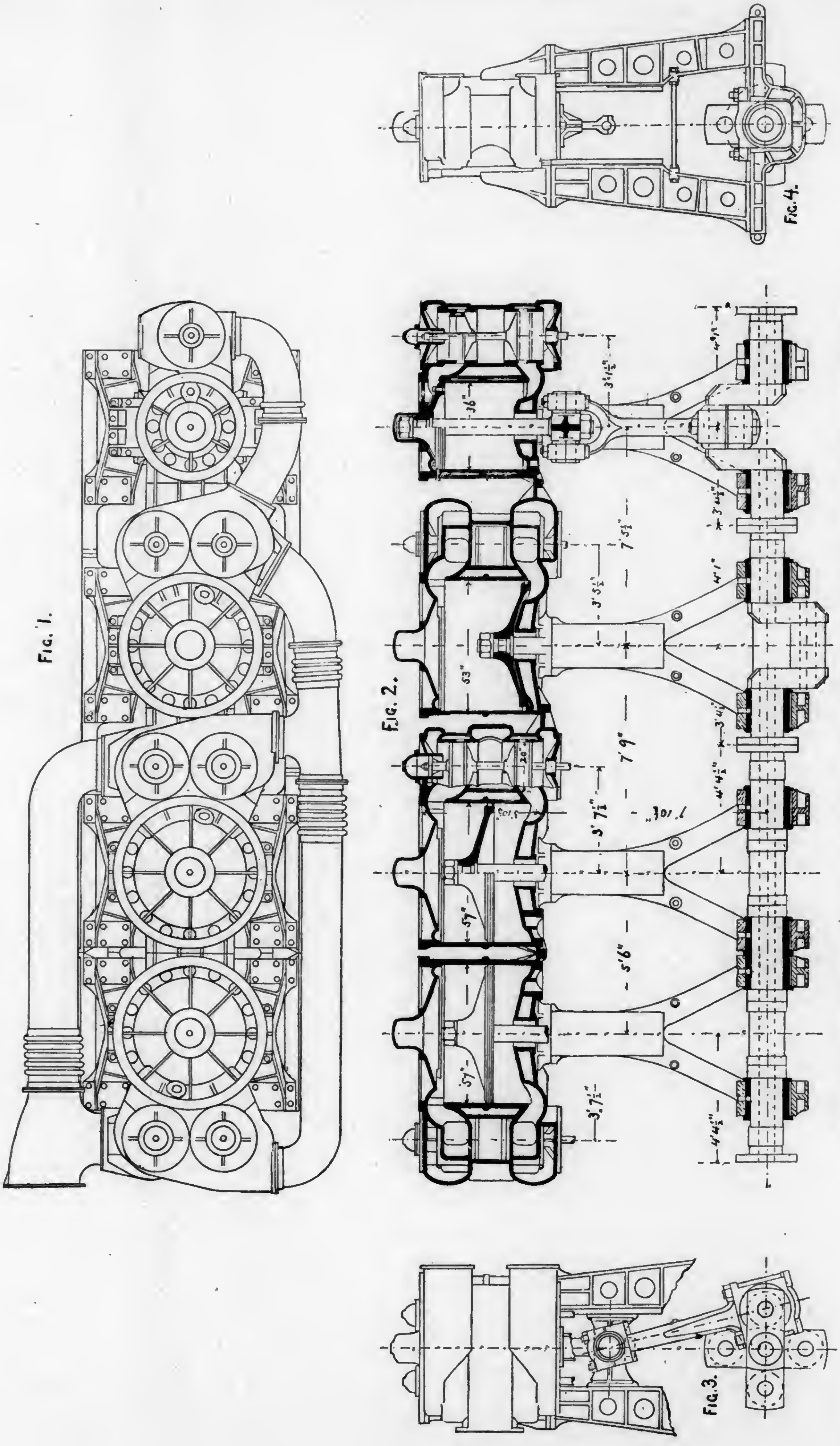
One fault found with these vessels is that, in consequence of the ventilation being very imperfect, it will be scarcely possible to employ them under a full head of steam in the tropics, out of consideration for the lives of the stokers; and yet this is the service for which they were specially designed.

The cost of the *Impérieuse* was $2,032,900 for hull, and $552,200 for machinery, or a total of $2,585,100 altogether, a far higher sum than is appropriated for the building of the new English cruisers now under construction of rather less tonnage but greater steam power.

UNITED STATES NAVAL PROGRESS.

THE contract for the two 1,000-ton gun-boats, officially known as Gun-boats 5 and 6, has been awarded to the Bath Iron Works, Bath, Me., at their bid of $637,000 for the two. These gun-boats were described and illustrated in the March JOURNAL; they are to be small, fast, steel cruisers provided with triple-expansion engines and twin screws, carrying a battery of rapid-fire guns. They will also carry a large supply of coal, and are expected to have a speed of 14 knots an hour.

No contract has been awarded for the practice ship for the Naval Academy. The bids of the Samuel L. Moore & Sons Company, of Elizabeth, N. J., for the gun-boats and the practice-ship were not considered in the final award, the



TRIPLE-EXPANSION ENGINES FOR CRUISERS NOS. 7 AND 8, UNITED STATES NAVY.

DESIGNED BY THE BUREAU OF STEAM ENGINEERING, NAVY DEPARTMENT: G. W. MELVILLE, CHIEF OF BUREAU.

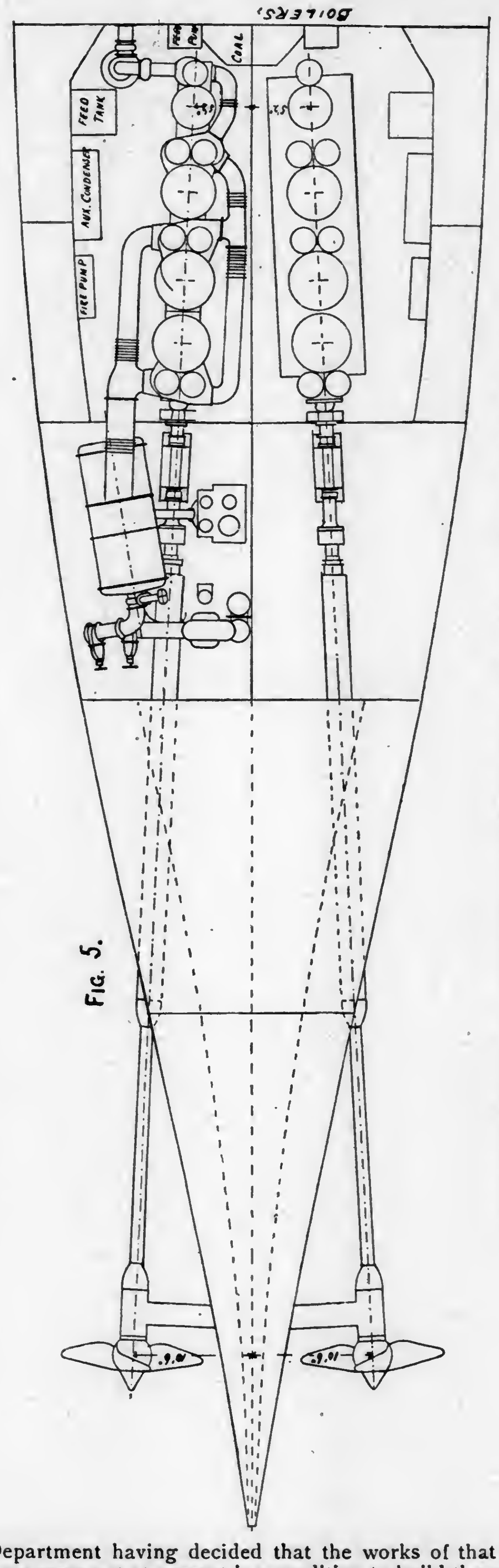


FIG. 5.

ARRANGEMENT OF ENGINES, CRUISERS NOS. 7 AND 8, UNITED STATES NAVY.

Department having decided that the works of that Company were not at present in a condition to build the vessels without delay.

ENGINES FOR THE 3,000-TON CRUISERS.

In the March JOURNAL a descriptionwas given of Cruisers Nos. 7 and 8, generally known as 3,000-ton cruisers. As there noted, these ships are to be twin-screw steel cruisers with heavy protective deck, having a length of 300 ft., a breadth of 42 ft., a mean draft of 18 ft., and a displacement of 3,183 tons. They will carry one 6-in. and nine 4-in. rapid-fire guns, with a heavy secondary battery.

The accompanying illustrations, which are taken from the Report of the Bureau of Steam Engineering, show the engines designed by the Bureau for these vessels. In these illustrations, fig. 1 is a plan of one of the engines ; fig. 2, a longitudinal section ; fig. 3, an end view from the after end, with the frame broken away to show the connecting-rod and cranks ; fig. 4, an end view from the forward end ; fig. 5, a plan showing the arrangement and position of the engines in the ship ; figs. 6 and 7, cross-sections showing the position of engine and boilers. Fig. 8 shows one of the boilers, giving a half front view, a half section and a longitudinal section showing one-half the length of the boiler. The description which follows is substantially that given in the Report of the Bureau.

These vessels are designed for a very high speed, and in consequence very powerful engines are needed to secure it. They are to be twin-screw, vertical, triple-expansion engines of 10,000 H.P. at full power, when making 164 revolutions with 160 lbs. pressure. The cylinders are 36 in., 53 in., and two of 57 in. diameter, by 33 in. stroke. Two low-pressure cylinders are fitted, because of the limited space athwartship, which would not have permitted a good arrangement with a single large cylinder. Each engine is in a separate water-tight compartment. The piston-valves

FIG. 6.

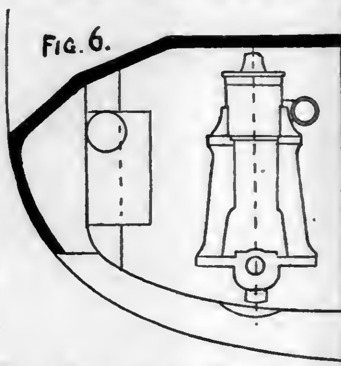
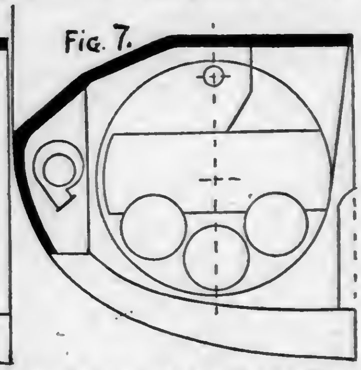


FIG. 7.



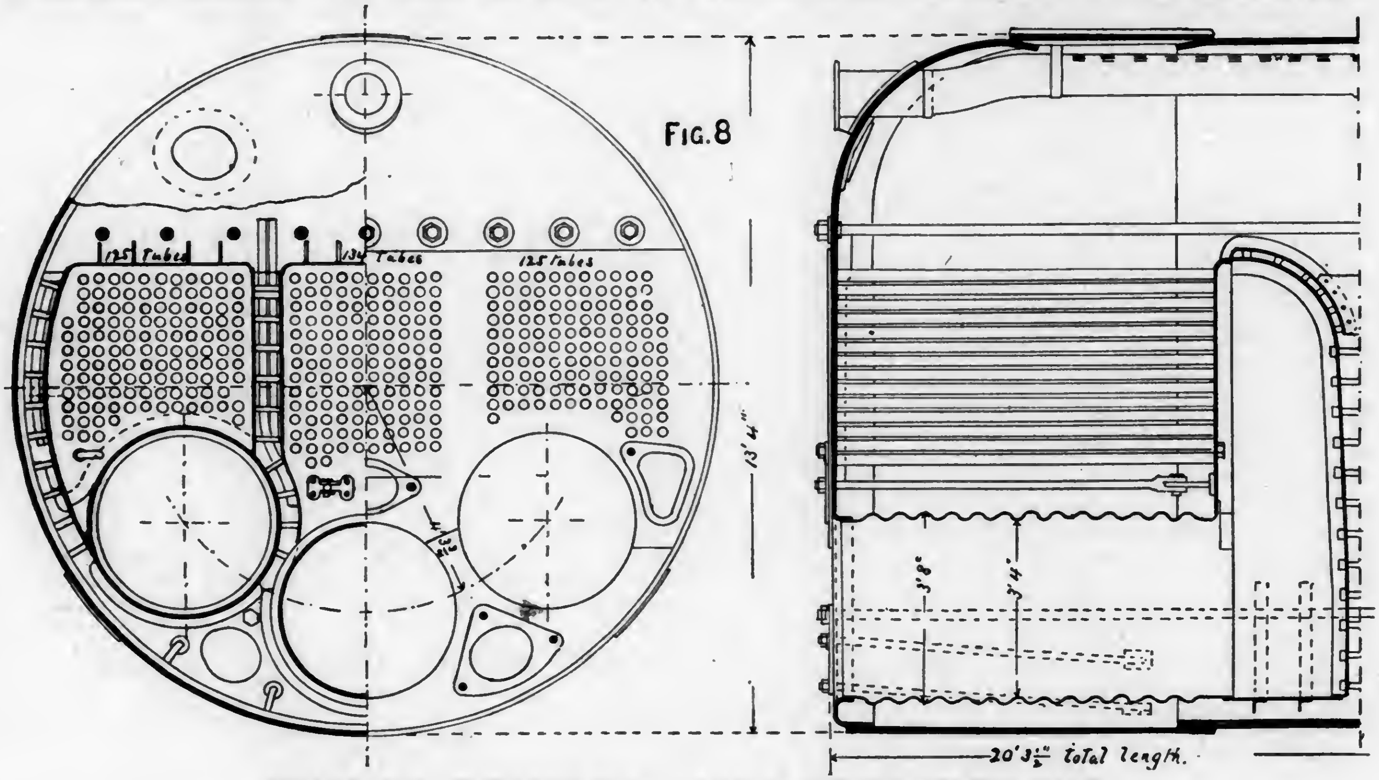
are all 20 in. in diameter, there being one for the high-pressure cylinder, two for the intermediate cylinder, and two for each low-pressure cylinder. They are all worked from Stephenson double-bar links. Provision is made in these engines, as in all the Bureau's recent designs, for adjusting the point of cut-off for each cylinder independently of the others, by making the attachment of the suspension-rod of the link to the arm on the reversing-shaft adjustable. The crank-shafts are in three sections, the two forward ones being interchangeable, and the after ones reversible. The two low-pressure cranks are placed opposite each other, as are the high-pressure and the intermediate cranks, the plane of these two being at right angles to that of the two low-pressure cranks. The journals are 13½ in. in diameter and the crank-pins 14½ in. in diameter, all with 6-in. axial holes. The thrust-shafts will be 13 in. in diameter with 6½-in. axial holes, and the propeller shafts 13½ in. in diameter with 6½-in. and 6-in. axial holes. The propellers will be three-bladed, of manganese bronze or equivalent metal, and about 14 ft. 6 in. in diameter.

The condensers will be cylindrical, of composition, 5 ft. 8 in. in diameter, and the tubes 11 ft. 6 in. long, each having a cooling surface of about 6,990 sq. ft. A valve is fitted in the exhaust-pipes from the low-pressure cylinders to shut them off when the condenser is used for auxiliary purposes. Each centrifugal circulating-pump will have a capacity of 9,000 galls. per minute when pumping from the bilge. There will be two vertical, single-acting air-pumps for each condenser, 18½ in. in diameter and 16½ in. stroke, worked by a compound engine.

There will be steam starting-valves, steam-actuated throttle-valves, steam and hydraulic reversing-engine, turning-engine, work-shop machinery, and the usual auxiliaries.

There will be four double-end and two single-end boilers of the usual return tubular type, all built of mild steel.

Two of the double-end boilers (fig. 8) will be 13 ft. 4 in. diameter and two 14 ft. $6\frac{1}{2}$ in. diameter, all 20 ft. $3\frac{1}{2}$ in. long. The shell-plates will be $1\frac{5}{32}$ in., $1\frac{15}{64}$ in. and $\frac{57}{64}$ in. in thickness respectively. The double-end boilers will each have six corrugated furnaces 44 in. in diameter for the large and 40 in. in diameter for the small ones. The single-end boilers will each have two corrugated furnaces 42 in. in diameter. The total grate surface is 607 sq. ft., and the total heating surface 20,167 sq. ft.



BOILER FOR CRUISERS NOS. 7 AND 8, UNITED STATES NAVY.

The same arrangements of the evaporators for the various purposes exists as in the other ships, the capacity being 5,000 galls. of potable water per day.

As heretofore noted, the bids received for these ships were all in excess of the amount appropriated by Congress for their construction. It was, therefore, decided to build them in the navy yards, and one of the ships is now under construction in the New York Yard and the other in the Norfolk Yard. The machinery for both vessels is being built at the New York Yard, work being now actively in progress.

LAUNCH OF THE "CONCORD."

The new gun-boat *Concord* was launched at the Roach yard in Chester, Pa., March 8. All the machinery is in place, and the ship more nearly completed than is usual at the time of a launch, so that she will probably be ready for the official trials about May 1. The *Bennington*, which is a sister ship to the *Concord*, will be ready to launch very soon at the same yard.

The contract for both these vessels was taken by N. F. Palmer, Jr., & Company, at $490,000 each. The hulls have been built at the Roach yard in Chester, and the machinery at the Quintard Iron Works in New York.

GUNBOAT "CONCORD," UNITED STATES NAVY.

The *Concord* is a light, unarmored cruiser or gun-boat of steel, divided by water-tight bulkheads into numerous compartments. The chief dimensions are: Length on load water-line, 226 ft.; beam, 36 ft.; depth, 18 ft. 9 in.; draft, 13 ft. forward, 15 ft. aft, or 14 ft. mean; displacement, 1,703 tons. The ship will carry three masts with fore-and-aft rig, and will have a sail area of about 6,350 sq.

ft. The accompanying illustration is a general sketch of the elevation, or side-view.

The *Concord* has two vertical, direct-acting triple-expansion engines, with cylinders 22 in., 31 in. and 50 in. in diameter and 30 in. stroke. The twin screws are three-bladed, 11 ft. 6 in. in diameter. Steam is furnished by four boilers, each 9 ft. 6 in. in diameter and 17 ft. 6 in. long. The engines are expected to work up to 2,200 H.P. with natural draft and 3,300 H.P. with forced draft, and the contract speed at full power is 16 knots per hour.

The main battery will consist of six 6-in. rifled cannon, two mounted forward, two aft and two in sponsons amidships. All are mounted on central pivot mounts, with segmental shields to protect the gunners, and have an arc of fire of 70°. The secondary battery includes two 57-mm. (2.24-in.) and two 37 mm. (1.46-in.) revolving guns and one Gatling gun. There are also eight torpedo-tubes: one forward, one aft and six in broadside.

The ship is lighted by electricity, and has an electric search-light. Two independent light plants are provided. Especial attention has been given to ventilation of fire-rooms and quarters, and to providing comfortable quarters for the officers and crew, who will number about 150 in all.

The cruiser *Newark* was to be launched at the Cramp yards in Philadelphia about March 17. The *Newark* is a steel cruiser of 4,000 tons displacement, much resembling the *San Francisco*, which was described in the December number of the JOURNAL.

THE NEW ARMORED CRUISER.

The Navy Department has issued a preliminary circular in relation to the armored cruiser provided for in the Act of September 7, 1888, for which the sum of $3,500,000 was appropriated, and for which propositions will be invited at an early date. This circular is issued beforehand so as to afford an opportunity to shipbuilders to submit independent designs for both hull and machinery. Secretary Tracy is desirous of having such designs.

This ship is to have a displacement of about 8,150 tons, with hull divided into numerous water-tight compartments. She is to have a speed of at least 20 knots an hour for four hours, which will be remarkably fast for an armored ship. The main engines are to be triple-expansion and four in number, two on each shaft, so arranged that the two forward engines can be readily uncoupled from the after engines, so as to make her an economical cruiser at low speed. Vertical armor is not to be relied upon so much as the protective deck, which will be armored 6 in. thick on the slopes over machinery and boilers, and 3 in. thick on the horizontal part. Forward and aft of the machinery, to stem and stern, the deck is to be, at the thinnest part, at least 2½ in. thick. If there is a sufficient margin of weight to admit of it, an armored belt 3 in. in thickness and extending 3 ft. above and 3 ft. below the normal water-line for the whole length of the ship will be carried. Within this armor belt a belt of woodite or other water-excluding material will be carried. The armored deck will be 1 ft. above the water-line amidships, and will slope to 5 ft. below the water-line at the sides. The conning-tower is to be protected by 7½ in. of armor.

The ship is to carry a battery consisting of four 8-in. breech-loading guns and sixteen 4-in. rapid-fire guns, with a secondary battery of four 6-pounders, four 3-pounders and four 1-pounder rapid-fire guns, four revolving cannon and four small machine guns. The 8-in. guns are to have a minimum horizontal train of 300°. There are also to be six torpedo tubes. The 8-in. guns are to be mounted in barbette turrets, having 10-in. armor, and are to be provided with revolving shields not less than 7 in. thick. The gun positions and ammunition-hoists are further to have cone-shaped armor not less than 5 in. thick, and the 4-in. guns are to have shields not less than 4 in. thick. The smaller rapid-fire guns are to be protected by extra heavy shields, and by thick plates on the sides.

The vessel is to carry 500 tons of coal at her normal displacement, and to have a total coal capacity of not less than 1,150 tons. The principal features of this cruiser are thus to be great speed, high coal endurance giving a great cruising range and the strength of the secondary battery.

INTEROCEANIC COMMUNICATION BY WAY OF THE AMERICAN ISTHMUS.

By LIEUTENANT HENRY H. BARROLL, U.S.N.

I.—HISTORICAL NOTES.

INTEROCEANIC communication between the Atlantic and Pacific oceans has occupied the minds of navigators since the discovery of the New World.

Columbus sought, not to give to his sovereigns a new world, but an uninterrupted water-highway to the East Indies, which for 3,000 years had been the storehouses of Europe, and the tales of whose splendor only reached Western Europe after a weary caravan journey of 300 days.

Succeeding navigators, therefore, instead of devoting themselves to the settlement of the new continent, sought diligently some way by which this barrier might be avoided.

Columbus ever believed that this continent adjoined Asia; and he persistently searched the whole coast, from Honduras to the Spanish Main, in the expectation of finding another Straits of Gibraltar, leading into another Mediterranean Sea, whereby his sovereign's ships might reach the mouth of the Ganges.

After the discovery of the Pacific in 1513, and later of the passage through Magellan's Straits by their illustrious namesake, a route to the West was shown, yet not a satisfactory one; and succeeding explorers examined every foot of the coast on both sides of the two Americas before mankind would concede that the two great oceans had not some connecting channel-way through this mighty stretch of lands.

After all efforts to discover a natural passageway had proven unsuccessful, the question then became one of forming an artificial channel.

Commerce demands uninterrupted and speedy transit. Centuries of experience have shown that when places are accessible by water, great disparity in distance does not enable transportation by land to compete with water transportation.

The fact that the general drift of the trade-winds and the equatorial currents from the Old World, westward, was stopped by this barrier, increased its importance, and the cutting through of the obstructing hills became a work of the greatest necessity.

The earliest project for a canal was that of the Spanish historian Gomarra, who, in 1551, urged upon Philip II. of Spain to unite the oceans by some one of the three routes now occupying the attention of the world—Tehuantepec, Nicaragua, or Panama.

Philip, however, was too much occupied with European affairs, and Spain was even then on her downward path, and no notice was taken of Gomarra's suggestion.

II.—PATTERSON'S ATTEMPT AT COLONIZATION.

The first real shape to any idea of transit across the Isthmus was given in the suggestion of William Patterson, the founder of the Bank of England, who attempted, in 1695–96, to establish a Scotch Company in opposition to that grand monopoly the East India Company.

Patterson was a man whose mind embraced all manner of subjects with unusual clearness, and he was the foremost statesman and financier of his time.

It was his intention to establish an artificial means of transit across the American Isthmus, and he engrafted upon his scheme the brilliant idea of controlling this strait and forming here the grand distributing center for the commerce of the world.

In 1695 a company was formed under a charter from the Scotch Parliament acknowledged by the King of England and having its headquarters in Edinburgh.

In London, in nine days, subscriptions to the amount of £300,000 were taken, while in Hamburg, £2,000,000 worth of stock was subscribed for. When we remember the limited coinage of that day, these figures show the enthusiasm with which the new company was received.

The first colonists left Scotland in July, 1698, and after a short voyage arrived at the Isthmus of Darien, founding a colony on a small peninsula jutting out into what is now known as Caledonia Bay.

The King of England, however, influenced by the East India Company, issued orders to the Governors of Jamaica and New York to withhold all supplies from the new colony, at the same time accusing the promoters of the colony of having treasonable designs.

Although harassed by disease and deserted by their own monarch, the hardy Scotch did not despair, and for some months continued their attempts at settlement of the country, but were finally driven to seek asylums among the other English colonies in the West Indies; and thus ended the only Scotch attempt at colonization.

III.—EARLY EXPLORATIONS.

After the departure of the Scotch colonists, the Spanish assumed control of Darien and the neighboring territory, and for some years attempted to obtain supremacy over the Indians, and to open regular transit by establishing a line of army posts extending between Caledonia Bay and Puerto Principio, an early Spanish settlement on the Rio Savana, a stream which empties into the Gulf of San Miguel on the Pacific side.

A trail was cut through the dense jungle, but nothing further was done for years, owing to the hostility of the Indian tribes.

Manuel Milla, the adjutant of one of the army posts on Caledonia Bay, in 1788 was ordered to make a reconnoissance across this route and reported in favor of the construction of a military road; but his suggestions were not acted upon, and two years later the Spanish abandoned this territory.

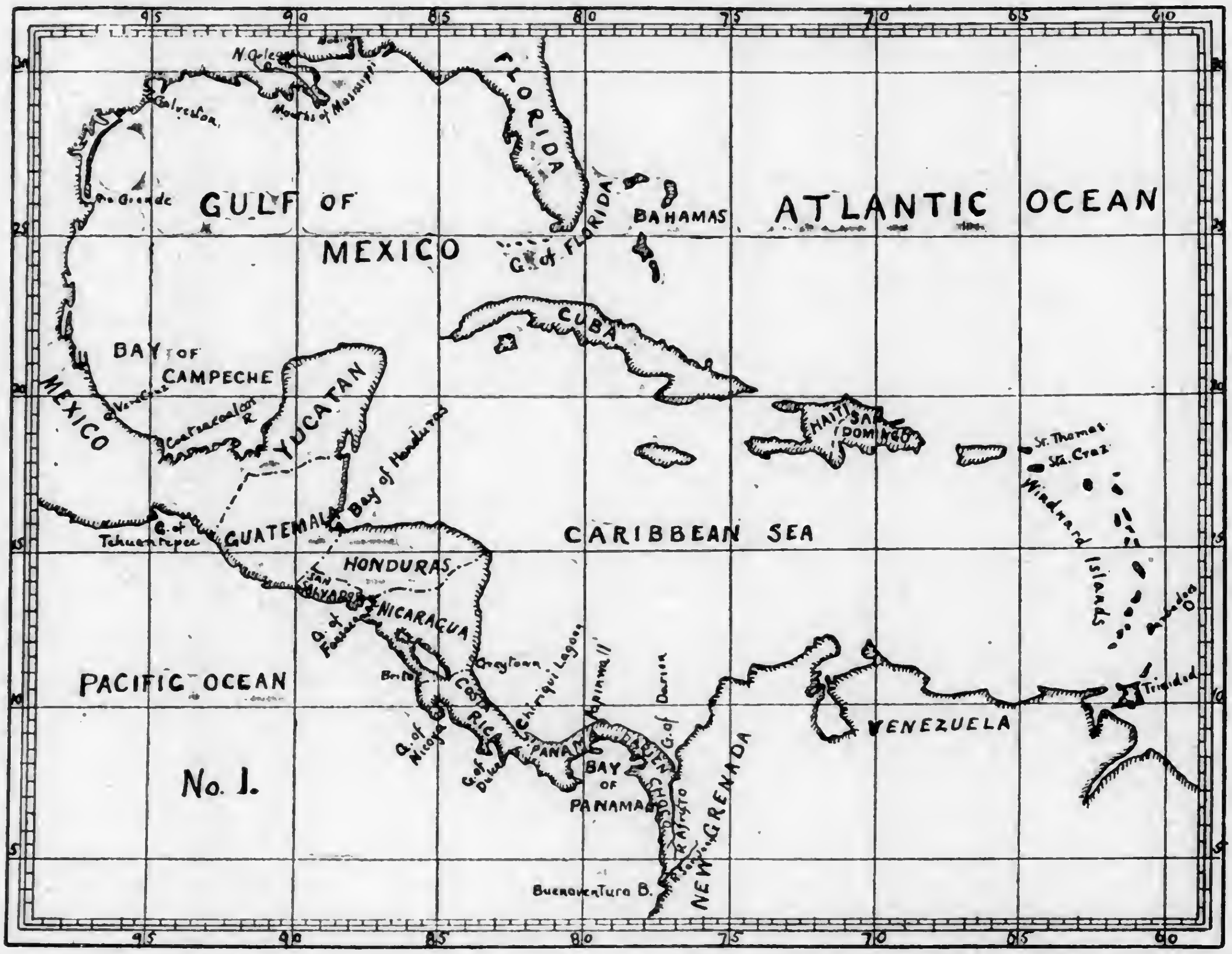
Humboldt, in 1808, called attention to the importance of interoceanic communication, suggesting the exploration of the several most probable routes; expressing his belief that a route either across the Isthmus of Darien, or by way of the Atrato River, would be the most practicable.

After the Spanish-American States had achieved their independence numerous explorations were made, chiefly with a view to internal improvement of the several States, but all productive of increased knowledge of the country.

In 1825, Señor Cañaz, at that time Minister from the Republic of the Center of America, addressed a letter to Mr. Clay, then Secretary of State, calling the attention of the United States to the importance of uniting the Atlantic and Pacific oceans, and desiring the co-operation of the United States, intimating that in event of a canal being built, its possession would be guaranteed to the two republics.

Both the President (Mr. Adams) and Mr. Clay thought favorably of this, and Mr. Williams, a newly-appointed Chargé d'Affaires, was instructed to examine carefully the facilities that Nicaragua offered for such a water-way, after which it was intended to lay the subject before Congress. Mr. Williams, however, seems not to have forwarded any information on the subject.

In 1825, there was a Governmental survey made across the Isthmus of Tehuantepec, which resulted in a brief but definite report, showing the impracticability of constructing a canal in this locality, owing to the high mountain ranges to be overcome and the poor harbor facilities at each terminus.



In 1828, while General Bolivar was President of the Republic of New Granada, a reconnoissance was made by Mr. John Lloyd across the narrow part of the Isthmus of Panama, with a view to determine a better route for land communication, and incidentally to determine the difference of level between the two oceans.

Until this time, neither the relative heights of the oceans, nor the elevations of the highlands of the interior, nor even the geographical positions of prominent points of this isthmus had been determined with any degree of accuracy.

The line of communication then used was that known as the "Porto Bello Road," a trail originated in the time of Cortez. Lloyd's report recommended that there be substituted for this a new route, starting from Limon Bay (Navy Bay) on the Atlantic side, which is substantially the line of the present Panama Railroad.

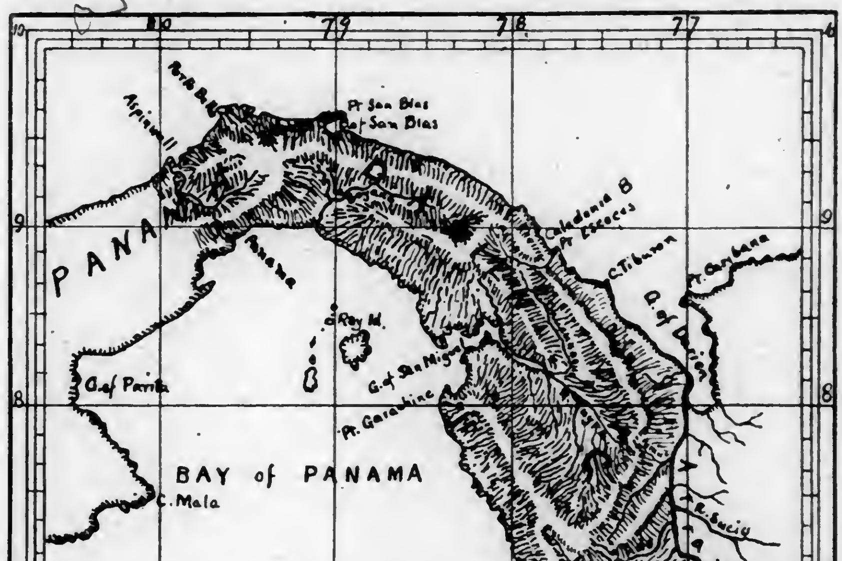
This survey also demonstrated that the mean height of the two oceans was almost the same; until this time a contrary opinion had existed with regard to this.

Numerous projects were entertained from time to time,

but not until after 1849 was public attention again drawn to this subject.

In the development of the western portion of the United States lies the power which has, in the last 40 years, rendered it imperative that our Government should take action upon this matter. Our acquisition of California and the Northwest Territory, the discovery of gold and the rapid increase in the population of the western coast of North and South America, demanded that all nations should combine to seek a practical solution of this problem.

The construction of the Panama Railroad, commenced in 1850, taught us much with regard to the general characteristics of that isthmus, while the through transit of goods and passengers emphasized the importance of an uninterrupted water-way.



The erroneous opinion that the Rocky Mountains and the Andes extended in unbroken continuity, was exploded, and it became well known that the greatest elevation to be crossed in passing from ocean to ocean, was, in dozens of places, only 800 ft. above sea-level.

IV.—CONTRAST BETWEEN THE AMERICAN AND THE EGYPTIAN ISTHMUSES.

It will be well here to examine the characteristics of this series of connecting isthmuses in order to more fully discuss the various routes that have from time to time been proposed.

Much surprise is manifested by those only generally informed on the subject, that the Isthmus of Panama remains a barrier to the same corps of engineers who so successfully completed the Suez Canal.

The Isthmus of Suez—some 120 miles in width—consists of a sandy depression, whose greatest elevation is only 50 ft. above the level of the sea.

Between the low sand-hills in this undulating tract of land, salt-water lakes occupied the lowest levels, and the work of piercing the Isthmus of Suez consisted in removing the sand from these dunes, and permitting the waters from the Mediterranean and the Red seas to fill the intervening hollows.

A glance at the map of Mexico and Central America shows the marked contrast between the American isthmus and that of Egypt. While the latter is a low-lying strip of sand separating two oceans, the former is a series of rugged mountain chains connecting two continents.

From the Coatzacoalcos River in Tehuantepec, where the continent of North America really begins to expand, to the Gulf of Darien, where South America may be said to commence, is one continued isthmus of some 1,250 miles in length, varying in width, owing to the indentations of the coast-line, but ever presenting a rugged, mountainous barrier.

This connecting strip consists of a series of isthmuses, all of which, with the exception of Nicaragua, have generally the same characteristics. They have a high "divide," which is generally found very near to one of the coasts. Near the sea-coast of that side having the most gradual slope are found low-lying alluvial deposits, forming lagoons, while there is a scarcity of good harbors on either side.

The rainfall of this tropical belt is an obstacle to be considered, while there exists an ever-present danger from earthquakes, naturally frequent in this section, which contains, in proportion to its size, more active volcanoes than any other part of the globe.

These volcanoes are all on the Pacific slope, and the Eastern slope, though in many cases consisting of broken mountain ranges, shows few traces of recent volcanic action. In the Nicaragua region the volcanic action has apparently exhausted itself, while throughout the whole of Central America, the earthquakes are not now of sufficient force to interfere seriously with a canal. The earthquakes occur most frequently at the time of the change of the tropic seasons —wet and dry.

The greater part of the isthmus lies in the neutral belt, between the northeast and the southeast trade-winds, a region of excessive rainfall, and having two distinct rainy seasons, during which the humid atmosphere causes malarious fevers, while at the same time stimulating excessive tropical growth of vegetation.

The trade-winds, born of the sun's warmth, follow it in its declination, the whole trade-wind system traveling a certain distance north, and then returning south, each year.

The Zone of Calms is from 5° to 7° in width, and travels through 16° or 18°, coming to 12° north latitude in the summer, and retreating to 5° south in the winter. All places in this belt are influenced by this trade-wind movement, and there are thus two well-defined rainy seasons experienced near the middle of the zone, while the edges have but one a year.

The Isthmus of Darien, and as far northward as 6° north latitude, experiences two rainy and two dry seasons each year, divided about as follows: From January to March, inclusive, is a dry season; from April to June, inclusive,

is a wet season; July, August, and September, dry; October, November, and December, a wet season.

The dry seasons, however, are not free from rain, but only so by comparison with the down-pouring rainfall of the wet seasons. The dry seasons are rendered pleasant by the trade-winds which at that time prevail; but in the wet seasons the calm, humid atmosphere is enervating in the extreme.

Heavy continuous rains have washed away the clayey mountain-sides, which, however, still give support to the trees, till now the protecting covering of leaves and roots serves as a shield to prevent further wash, while the rank vegetation finds foot-hold in the crevices of the disintegrating rock. The sharp, serrated profiles of the mountains alternate with low-lying jungles of thickly-matted vines, through which the explorer must cut each foot of the way.

In Darien, and in the valley of the Atrato River, existed hostile Indian tribes, who, in their ignorant fear of having their homes invaded, did all they could to harass and destroy the reconnoitring parties.

Hundreds of venomous reptiles and poisonous insects infest this tropical region, secure beneath its perpetual foliage until they have inflicted the deadly bite or painful sting.

The annual rainfall at Aspinwall is 124.25 in., while at Cairo, in Egypt, the mean annual rainfall is only 1.3 in. The total rainfall noted at Aspinwall for the month of November, 1870, was 32.5 in., or 25 times the yearly rainfall on the Isthmus of Suez.

There could not be a greater contrast between two connecting strips of land than the difference existing between the American isthmus and the isthmus of Egypt.

V.—THE EXPLORATIONS MADE BY MR. KELLEY.

To make explorations through unhealthy dense forests inhabited by hostile savages, required such expensive outfits that few private explorations were attempted, and these productive of but little additional information; yet the first expedition of importance was, nevertheless, undertaken by a private individual, Mr. F. M. Kelley, a wealthy citizen of New York, who, purely in the cause of science, interested himself and his fortune in the attempt to discover some feasible line for a ship-canal.

Humboldt had cited either Darien or the valley of the Atrato, as the most favorable region, and Mr. Kelley determined to investigate these localities.

He engaged the services of the eminent engineer J. C. Trautwine, who in 1852 made an exploration to prove or disprove an existing legend that a small canal had been constructed and used by natives to transport canoes from the head-waters of the Atlantic to those of the Pacific streams.

The legend called this the Raspadura Canal, and located it as connecting the head-waters of the Atrato and the San Juan rivers. The Atrato is a large stream taking its rise in the mountains in about 5° north latitude, and, flowing northward, empties into the Gulf of Darien. The San Juan is a smaller stream, which takes its rise near the same place, and flowing southwesterly empties into the Pacific, just north of Buenaventura Bay.

Trautwine's survey disproved this legend, and his report was adverse to any attempt at water communication by this route. Notwithstanding this unfavorable report, Mr. Kelley was not disheartened, and in 1853 he organized two additional exploring parties—one under the command of a Mr. Porter and the other commanded by Mr. Lane, but their results only confirmed Trautwine's report.

Mr. Kelley, determined not to be baffled, then began the search for a route by way of the Truando, one of the western tributaries of the Atrato. This route was explored by Lane and Kennish, under the supervision of Mr. Kelley, the only success attending their work being that Kennish clearly established the fact that the two oceans had the same mean level.

Although failing in his undertaking, yet the earnest work of Mr. Kelley had the effect of causing the Government of the United States to become interested in the affair to that extent that an official expedition, with the consent of the Government of New Granada, surveyed a route by way of the Truando River in 1857. This, however, still further demonstrated the hopelessness of constructing a canal in this region, owing to the numerous ranges of mountains.

The strong political feeling which prevailed for the next few years, and which culminated in the breaking out of the Civil War, prevented further action being taken by the United States Government.

VI.—DR. EDWARD CULLEN'S ROUTE.

In 1850, Dr. Edward Cullen, of Dublin, Member of the Royal Geographical Society of Great Britain, having secured a concession from the Government of New Granada, presented before the Edinburgh meeting of the British Association a project for a ship-canal across the Isthmus of Darien, which resulted in the reconnoissance of the proposed route by Mr. Lionel Gisborne, Civil Engineer.

This route was to extend from Caledonia Bay on the north to the Gulf of San Miguel on the south, being substantially that suggested by the Spanish adjutant Milla, 60 years before, as a suitable line for a military road.

Gisborne, in his attempted exploration, trusted largely to the views which met his eye when standing upon the higher divides—a source of almost certain error in a thickly-wooded country—and his erroneous report caused the belief that there here existed a level plateau having a greatest elevation of some 150 ft. above the level of the sea.

There were several attempts to verify Gisborne's assertion to this effect, all of which resulted in much loss of life. His route was explored by Commander Prevost, of the British Navy, in 1853-54, and also by Lieutenant Strain, of the United States Navy, in 1854. Both expeditions were attended with great suffering and loss of life, since these commanders trusted to the statements that Gisborne had made.

Prevost started from the Pacific side, and attempted to cross to Caledonia Bay by the route which was supposed to lead to that point; but owing to the poor geographical knowledge possessed at that time, his course was directed too far to the northward, and he finally returned, to find that some of his men, who had been following in the rear, had been massacred by the Indians.

The story of Strain's expedition across the Isthmus is well known. It is a repetition of the record of daring, courage, and fortitude under suffering, that characterizes the Anglo-Saxon race. It is unnecessary to do more than briefly allude to it in this article.

VII.—STRAIN'S EXPEDITION.

Led by the report of Mr. Gisborne to believe that this plateau existed a few miles inland at this point, Strain, attended by a party of volunteers, left the United States ship *Cyane*, anchored in Caledonia Bay, and attempted to trace a line of transit from this bay to strike the Savana, one of the rivers flowing into the Gulf of San Miguel. It was known that the *Virago*, a British vessel of war, was anchored in the Gulf of San Miguel, and that she would furnish all possible assistance to the exploring party when it should reach the Pacific coast, and therefore only a limited supply of provisions was carried.

The explorers were successful in securing Indian guides from the tribes of the interior, and on January 21 started inland, following along the tortuous and almost indiscernible trails cut by their Indian guides.

Strain almost immediately found his way obstructed by mountain ranges from 1,000 ft. to 3,000 ft. in height, where Gisborne had declared over his professional signature that he had found an elevation of only 150 ft.

Strain, therefore, kept away to the northward along the mountain chain, in the hope of finding this pass. Continually seeking this plateau, and meeting only mountain chains, the party proceeded farther and farther inland; their scanty stock of provisions became exhausted, and they found but small means of procuring food from the frightened natives, who, deserting their homes, took all sustenance with them, so that our explorers found only desolate huts. But imbued with the idea that they must soon reach this pass, they pressed onward, finally following to the southwest the course of a stream of considerable size, which we now know as the Chucunaqua River, only to meet disappointment at each succeeding turn.

Deserted by their treacherous Indian guides, who had purposely misled them, and weak and exhausted from insufficient food, the little band on February 13 separated; Strain hurrying forward, with three of the hardier members of the party, to obtain assistance, while the remainder, under Passed Midshipman (late Commodore) Truxtun, after following for some days down the Chucunaqua, and concluding that Strain and his companions had been murdered, retraced their steps and attempted to regain the *Cyane* on the Atlantic side.

Strain, exercising all haste, managed on March 9 to reach Yavisa, a small settlement on the Chucunaqua, and in communication with the Gulf of San Miguel, and immediately returned with food and assistance furnished by the *Virago*, the sturdy Britons rowing night and day; yet he did not overtake Truxtun's party until it had gotten halfway back to Caledonia Bay.

The party was over two months struggling through this jungle, some days not making more than one mile in advance. Several died of starvation, and all suffered terribly from the effects of the journey, two members dying after their rescue. During this entire time perfect discipline was maintained, and the record of the expedition is filled with deeds of heroism and unselfishness.

The results of the expeditions under Strain and Prevost did not yet cause the abandonment of this route as a possible line. Dr. Cullen succeeded in interesting in this project M. Roger, of Paris, who founded the Société d'Études, under the direction of which society M. Bourdiol, a prominent engineer, attempted a resurvey of this line, to meet, however, with disappointment, owing to the desertion of his negro workmen upon nearing the interior, through fear of the Indian tribes.

Nevertheless, the enthusiastic Bourdiol felt competent to make estimates for a canal, and did so, designing a canal 31 miles in length to overpass an elevation of 144 ft., and to be furnished with 22 locks, 11 on each side. The cost of this visionary canal was to be $34,000,000.

Mr. Gisborne subsequently made a more careful exploration of this route, which resulted in the determination of the *lowest* divide with an elevation of 930 ft.!

NOTE BY THE AUTHOR.

In the compilation of this article and of those which will follow it, I have been allowed by the Navy Department to use all data connected with the subject.

I have taken the liberty of reproducing much of the information contained in the report of Lieutenant J. T. Sullivan, U.S.N., prepared by direction of the Secretary of the Navy, and printed in 1883. The early history of the explorations, as well as the short account of Strain's expedition, have been mainly taken from Lieutenant Sullivan's report.

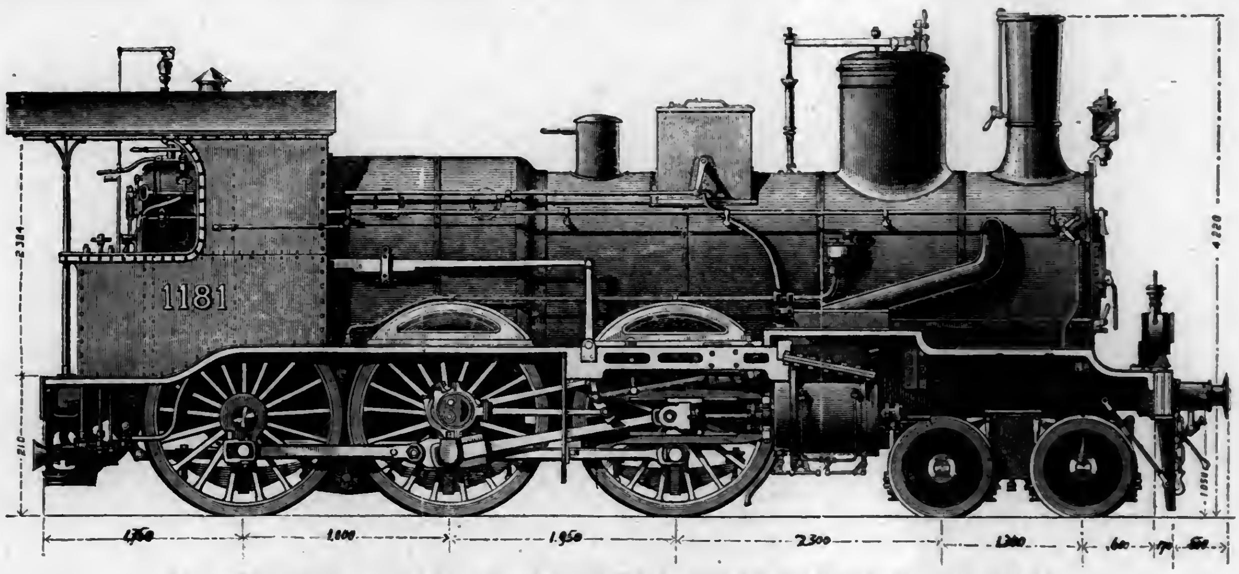
I have also made use of the Report of Commander Thomas O. Selfridge, U.S.N., printed in 1874, and that of Civil Engineer A. G. Menocal, U.S.N., published in 1885. I desire to return my thanks to the President of the Nicaragua Canal Company, as well as to Commander H. C. Taylor, U.S.N., for the latest data with regard to the Nicaragua Canal.

(TO BE CONTINUED.)

AN ITALIAN TEN-WHEEL LOCOMOTIVE.

THE accompanying illustration, from the London *Engineer*, shows a locomotive with six drivers coupled and a four-wheel truck, designed for the Italian Mediterranean Railroad by Commendatore Frescot, Chief Engineer of Motive Power of that road. It was specially intended for working the through passenger and fast freight trains on the Company's line between Genoa and Alessandria, which has some heavy grades on the section crossing the Appenines. The through passenger trains are required to make a speed of 50 km., or about 31 miles, an hour, on this section, which includes one grade about 14 miles long of 91 ft. to the mile, with several curves of 984 ft. radius. The first engine of this type was built at the Company's shops at Turin, and proved so successful that 40 more have been built with but slight modifications from the original locomotive.

The boilers of these engines are 60 in. in diameter of barrel and 18 ft. 6 in. in length over all. They have 203 tubes $2\frac{1}{16}$ in. in diameter and 15 ft. long. The fire-box is 7 ft. 8 in. in length and 3 ft. 3 in. in width. It is on the Belpaire system, the flat crown-sheet being connected to the outside shell by wrought-iron stays. The fire-box is of copper and the tubes of brass. The grate area is 24 sq. ft., the fire-box heating surface 114 sq. ft., and the heating surface of the tubes 1,600 sq. ft. The grate is inclined. The usual working pressure carried is 150 lbs.



TEN-WHEEL LOCOMOTIVE, MEDITERRANEAN RAILROAD OF ITALY.

The cylinders of these engines are $18\frac{1}{2}$ in. in diameter and $24\frac{1}{2}$ in. stroke. The slide valves are on top of the cylinders, and the valve-motion is all outside. Gooch's valve gear is used, with screw reversing gear. The piston-rods, cross-heads, and connecting-rods are all of steel, and metallic packing is used in the stuffing-boxes. The piston-rods are screwed into the iron pistons.

The driving-wheels are 5 ft. 6 in. in diameter, and the total rigid wheel-base is 13 ft. The four-wheel truck has wheels 33 in. in diameter, placed much closer together than is usual in our practice, the cylinders being, as shown, entirely back of the truck. The total wheel-base of the engine is 24 ft. The axles and tires are of steel, and both driving-wheels and truck-wheels are of wrought iron.

As is usual in European practice, the frames are of the plate type, the plates being $1\frac{1}{8}$ in. thick. They are braced together by several cross-stays, two of which, under the smoke-box, carry the bearings for the truck.

The engine has a blast nozzle, with a valve for increasing

or diminishing the area of the opening. It is provided with the Westinghouse air-brake and with driver-brakes. There are two Friedman injectors for supplying the boiler. The cab is of sheet-iron, and the dome is placed on the forward end of the boiler.

The chief peculiarities of the engine to our eyes will be the position of the valve gear outside and the carrying of the cylinders back of the truck. This seems to be a somewhat awkward arrangement, requiring a long steam-pipe, with a considerable portion outside of the boiler.

The tender is carried on six wheels of 44 in. diameter, with inside axle-boxes, and has a capacity of 2,200 galls. of water and $3\frac{1}{2}$ tons of coal. Its total weight is 15 tons empty and $28\frac{1}{2}$ tons loaded.

HORATIO ALLEN.

(*Concluded from page* 117.)

In 1834, after the South Carolina Railroad was finished, Mr. Allen married Miss Mary Moncrief Simons, daughter of the Rev. James Dewar Simons, of Charleston. He remained in Charleston until 1835, and in the spring of that year he went abroad, accompanied by Mrs. Allen, and devoted nearly three years to foreign travel, returning to America near the close of 1837. During that time he made the entire passage of the Danube to the Black Sea and Constantinople, went thence to Smyrna, the Asiatic Coast, to Athens, and across the Levant to Alexandria, and spent the winter on the Nile; returning in the spring of 1837, he went to Naples, and from there to England, through the principal cities of Italy, Germany, and France, embarking for the United States late in 1837.

In 1843 he received the appointment of Principal Assistant Engineer of the Croton Aqueduct, John B. Jervis being the Chief Engineer. Before the High Bridge over the Harlem River was built, Mr. Allen recommended that the Croton Aqueduct be carried in a tunnel below the river. Since then this plan has been adopted for the new aqueduct, which now passes under the river. On the completion of the Croton Aqueduct, in 1844, he first turned the water on to supply the city of New York. Afterward he was appointed one of five commissioners who were intrusted with the supervision of the distribution of the water through the city.

About 1844 Mr. Allen became a member of the firm of Stillman, Stratton & Allen, who were the proprietors of the celebrated Novelty Works in New York. This establishment originated in a somewhat curious way. Previous to the date when this firm was organized Dr. Knott, then President of Union College, invented a stove and a steam boiler for burning anthracite coal. To show the entire practicability of his invention he had a small steamboat built called the *Novelty*, which ran from New York to Harlem. At night this boat was laid up at a landing at the foot of Twelfth Street. A small shed was then erected there, with a few tools for doing repairs on the boat. This shop was extended, and it came to be known as "The Novelty's Works." This shop passed into the hands of Mr. Stillman, who extended it and did various kinds of machine work there. After Mr. Allen entered the firm the business, grew very rapidly in various directions, and included mill-work of various kinds, stationary and marine engines, pumps, sugar machinery, steam fire-engines, hydraulic presses, etc.

The firm of Stillman, Allen & Company was formed in 1847, and consisted of Thomas B. Stillman, Horatio Allen, Robert M. Stratton, George F. Allen, and William B. Brown. The Novelty Works finally became the largest establishment in the country for building marine engines. The machinery for many of the old Collins Line of steamers and the Pacific Mail Steamship Company, was built there, including the engines of such ships as the *Pacific*, *Atlantic*, *Adriatic*, *Arctic*, and *Baltic*. All these had side-lever engines excepting the *Adriatic*, which had oscillating engines, with two cylinders 9 or 10 ft. diameter and 13 ft. stroke.

Mr. Allen was always a great advocate of oscillating cylinder engines for side-wheel steamships, and in 1867 he wrote what he called "a statement of facts and considerations in reference to beam and oscillating engines for marine side-wheel steamships," which was addressed to Allan McLane, President of the Pacific Mail Steamship Company, and was afterward published in a pamphlet. In this Mr. Allen compared engines with 85-in. cylinders and 8 ft. stroke, and claimed that the room occupied by the oscillating engine compared with the beam engine is 8,500 cubic feet for the one and 14,750 for the other; the weight 138 and 152 tons respectively; the number of parts through which the power is transmitted from the piston to the crank is three for the oscillating engine and nine for the beam engine; the number of parts which must be constructed in true line and relation to each other is three for the oscillating and six for the beam engine; the number of bearings and their brasses to be kept in proper adjustment and lubrication is five for the oscillating and 13 for the beam engine. He also explained that the structure through which the power was transmitted from the cylinder to the crank-pin would be much stronger and more substantial, and the strain on the bottom of the vessel less with the oscillating than with the beam engine; the weight, which comes to a state of rest in passing the centers is $6\frac{1}{2}$ tons in the one engine and 30 in the other; the valve-gear of the oscillating engine, it was admitted, has more parts than that of the beam engine. It was also claimed that all the journals of the oscillator are as accessible as those of the beam engine, that the first could be balanced by cast-iron buckets on the wheel as perfectly as the latter is by the weights at each end of the beam.

The *Adriatic* had oscillating engines, and Mr. Allen applied his valve-gear to them, which consisted of large conical plug-valves. These were moved by a mechanism which first lifted the valves and then turned them, which it was supposed would prevent them from jamming. There was considerable difficulty in getting them to work satisfactorily. This caused much delay and involved a heavy expense. Some part of the gear broke down on a trial trip, and the valves were finally taken out and others were substituted for them. As there was great rivalry at that time between the Cunard Line—which was owned by Englishmen—and the Collins steamers, which were owned by Americans, this experimental valve-gear attracted a great deal of attention, and was the subject of much criticism.

The engines for the *Constitution*, *Moses Taylor*, *Ancon*, *Mariposa*, *Great Republic*, *Idaho*, *Montana*, *Arizona*, *Golden Age*, and *Golden Gate* for the Pacific Mail Steamship Company were all built at the Novelty Works. The *Golden Gate* also had oscillating engines.

During the War engines were built for three gun-boats and also for the sloops *Adirondack* and *Wampanoag*, and the double-turreted monitor *Miantonomah*, and the frigate *Roanoke* was converted into a monitor with two turrets. The old engines were used in the vessel when it was altered.

At one time there were over 1,500 men employed in the Novelty Works, but so great was the difficulty of getting men at that time, that Mr. Allen went to Europe and employed a large number there who were brought over.

It was during the War that the somewhat acrimonious dispute, with reference to the economy of using steam expansively arose. On the one side were those, including Mr. Isherwood, the Chief of the Bureau of Steam Engineering, who advocated the use of comparatively low pressure and moderate degrees of expansion in the engines then in use; and on the other side was the late Mr. E. N. Dickerson and others, who claimed that greater pressures and excessively high degrees of expansion were the most economical. The subject was discussed on both sides with great fierceness and attracted the attention of Congress, and finally the Naval Committee requested the Naval Department to have a series of experiments made "to assist in determining the limitation of the economical expansion of steam under practical conditions, and other collateral questions relating to the general subject." *

The experiments were to be made under the supervision of a Committee of the Franklin Institute of Philadelphia, and the Smithsonian Institute of Washington, and three

* Paper on the Cost of Power in Non-Condensing Steam Engines. Read by Charles E. Emery before the American Society of Mechanical Engineers, 1888.

civilian engineers, of whom Mr. Allen, who believed in high rate of expansion, was one. If Committees were appointed by the Institutions named, they did not take an active part in conducting the experiments. These were made during the years 1864 to 1868 at the Novelty Works, under the general direction of Mr. Allen, who was then the President of the Company, and Chief Engineer Isherwood, at that time the Chief of the Bureau of Steam Engineering, U. S. N., who detailed a corps of assistants to do the work.

The experiments were commenced at the Novelty Works on a large scale. Engines with various-sized cylinders were constructed. These were connected with a large air fan, the revolutions of which represented the work done. Much time and money was consumed in getting this machinery to work satisfactorily, and in making the experiments, and apparently they did not prove exactly what either side anticipated. While they were insufficient to settle all the points at issue they showed what is well known now, that the point of cut-off which is most economical becomes shorter as the pressure is increased, but that with any pressure, the most economical degree of expansion is soon reached and the cost rises rapidly after this point is passed.

So much time was consumed in making the experiments that some of those who formed the Commission lost interest and practically abandoned them, possibly because the results did not prove what it was expected they would. The work was then carried on by Chief Engineer Isherwood and his assistants in consultation with Mr. Allen. The cost of the experiments went up to over $100,000, and as the time consumed was so great and the results were apparently inconclusive, the Navy Department finally ordered them discontinued. The Commission in charge of them never made a report nor were the results published under Government authority, although a general table was furnished by Mr. Isherwood to Mr. R. H. Buel, who had it published in the articles on Steam Engineering which he prepared for Appleton's Cyclopædia of Mechanics and in the American edition of Wiesbach's Mechanics.

It is not easy now to learn what was the precise significance, or rather what was proved by these experiments. Apparently they did not show as great an economy from the use of high-pressure steam and high rates of expansion as the advocates of that side of the question expected, though the results with high-pressure steam showed greater economy than those with low pressure, and it was also found that it was economical to cut off shorter with high than with low-pressure steam. The experiments were, of course, made with engines of the kind then in most general use, and did not include compound or triple-expansion engines with the very high pressures which have been made practicable by their use. It is evident now that those who then advocated the use of high-pressure steam and excessively high degrees of expansion, did not understand fully how steam used under these conditions is affected by various circumstances, especially those existing when steam is expanded in a single-cylinder engine.

Afterward, a competitive trial was made by Commodore Isherwood and Mr. Dickerson with two United States vessels, the *Winooski* and the *Algonquin*. They were first tied up in a dock and their wheels were turned at a regular rate and a careful record was kept of the fuel consumed. In these trials the *Winooski*, Commodore Isherwood's vessel, had an engine with double poppet-valves and Stevens cut-off. The *Algonquin* had a Sickles cut-off with single poppet-valves.

Trials of speed were afterward made at sea. The *Winooski* then used steam of 25 lbs. pressure cut-off at $\frac{6}{10}$ of the stroke, and the *Algonquin* carried 90 lbs. of steam and cut-off at $\frac{1}{10}$.

The failure of the *Algonquin* in these trials is now a matter of history.

After the experiments at the Novelty Works were ended, Mr. Charles E. Emery, who was an assistant engineer in making them, suggested a supplementary series with a small engine having 8 × 8 in. cylinders. The officers of the Novelty Works agreed to bear the expense of these which amounted to about $5,000. The results of these experiments with non-condensing engines were afterward published by Mr. Emery in the proceedings of the American Society of Mechanical Engineers in 1886 and 1888.

While the investigations were being made, it is said that Mr. Allen suspended judgment thereon, as was proper he should. Those who were intimately associated with him at the time never heard him express an opinion with reference to the subject after the experiments were ended.

In the light of our present knowledge it seems singular that experiments on such a scale were needed to show what now seems so easily proved. Doubtless some of the experiments of the present day will appear equally needless 25 or 30 years hence.

During all of Mr. Allen's career he was a prolific inventor, as will appear from the following list of patents which he took out:

Steam Cut-Off H. Allen	1841
Stop Cock "	1841
Steam Cut-Off "	1842
Determining Thickness of Metal Pipes. H. Allen	1843
Tapping Mains. H. Allen	1843
Steam Cut-Off "	1847
Steam Cut-Off "	1849
" " " "	1849
Steam Engine Valve-Gear, Allen & Wells	1853
" " " " " "	1853
" " " " H. Allen	1857
Steam Boiler Tube Joint "	1858
Car Seats and Couches	1866
Connecting the Tubes with the Heads of Surface Condensers. H. Allen	1868
Sleeping Cars	1876
Terrestrial Globes	1879

The Allen & Wells cut-off, in its several different forms, was introduced to some extent, and is still in use on different steamboats. The method of connecting condenser tubes to their heads, with compressed wooden ferules, has also been extensively adopted.

During the War, although a great deal of work had been done at the Novelty Works, the success of the Company was not proportionate to the amount of the business. They were operated during part of that period under the disadvantage of a market in which the prices of labor and materials were constantly rising. Contracts were taken at fixed sums, and it was then not easy to anticipate what the increase would be in the cost of doing work before it was finished.

When the War was ended there was, of course, a cessation of Government work. Business at the Novelty Works had been conducted on a large scale, with fixed expenses in the same proportion. The tools and machinery were old and out of date, and it was soon found that the Works were being conducted at a loss. To remodel and re-equip them with new tools and machinery to meet the changed condition of business, would involve a large outlay of capital. The real estate was very valuable, and it was finally determined to close the Works and wind up the business. This was done in 1870 and the Novelty Works soon ceased to exist. The business which was conducted then, like most great enterprises, was attended with varying success. Under the firm of Stillman, Allen & Company it was at first very profitable, but some heavy losses embarrassed the firm and they had to seek outside aid. Mr. James Brown furnished the firm with more capital, and when a stock company was organized he became a stockholder. During the War the business was very active and during part of the time profitable, but Mr. Allen was then not a large holder of the stock.

During his connection with the Novelty Works he also acted in the capacity of Consulting Engineer for the Erie Railroad. He was also Consulting Engineer to the Panama Railroad Company for a short time, and during that period also held incidentally other important engineering trusts. His professional career may be said to have ended as Consulting Engineer of the Brooklyn Bridge.

In 1870 Mr. Allen retired from active life and built himself a house in a retired spot near Mountain Station, on the Morris & Essex Railroad in New Jersey, where he resided up to the end of his life. He left a widow, three daughters, and a son. He always seemed to derive his chief enjoyment in life from his delightful home, but this was especially the case during the latter years of his life.

He was a man of very quiet domestic tastes, but took a lively interest in engineering, scientific, and especially educational matters, up to the last.

He was brought up an Episcopalian, but in early life became one of the prominent members of All Souls' Unitarian Church, under the charge of the Rev. Dr. Bellows, and always took an active interest in philanthropic and charitable matters. He was one of the founders of the Union League Club, and an active member of it in the days when its influence was exerted in behalf of great national questions, and before narrow partisanship had contracted its sphere of usefulness. He was also one of the organizers, and for a long time an active member, of the Association for the Improvement of the Condition of the Poor, the Children's Aid Society, and the New York Gallery of Art, which was instrumental in preserving what was known as the Abbott Collection of Egyptian antiquities, which now forms a part of the New York Historical Society's collection.

Mr. Allen took an interest in a very wide range of subjects. During his later years he devoted much time to the subject of education, and was especially interested in the methods of teaching astronomy. He wrote a book on that subject and invented and constructed a number of instruments to facilitate the study of astronomy in schools. He also wrote an elementary book on arithmetic, with a view of simplifying the methods of teaching.

His life and experience, if it could be fully written, would be of exceeding interest.

In his later years he often expressed regret that he did not keep a record of the events of his early life, and especially his observations during the period that he first visited Europe. He was then on intimate terms with George Stephenson and the early fathers of the railroad system. He was in England to study that system, which was then, if not in its infancy, at any rate in its early youth. If his observations had been fully recorded, they would now be of intense interest. Beginning his study of engineering in early manhood, when railroads were an experiment, it extended over the period, so recently ended, which covered completely that wonderful era of modern development which has been due to the introduction, application, and diffusion of steam-power over the whole civilized world.

Among the marked traits of Mr. Allen's character were his gentleness and generosity, which it is said "is in nothing more seen than in a candid estimation of other men's virtues and good qualities." He was always ready to give a helping hand to those who were down and trying to get up. His words and acts of encouragement to many young men beginning the hazardous voyage of life, were like propitious breezes and inspired them with hope which sustained them until they reached port. A paper published near his home said of him: "His integrity was of the most unswerving, unflinching kind, and he was scrupulous almost to a fault over matters that ordinarily pass current in the mercantile world." The modern forms which business bribery has assumed excited in him unbounded indignation. A gentleman occupying a prominent position in public life, and who was associated with Mr. Allen during one of the most trying periods, said of him, he was "a true gentleman of the old school."

His last years were spent quietly with his family in his home near South Orange, in New Jersey. It may be said of him that his integrity commanded the respect of all honest men who knew him; his generosity made many persons his debtors, and the delight which he took in contributing to the happiness of others led all to be "kindly affectioned" to him.

AN IMPROVISED ICE-HOUSE.

SOME PRACTICAL WARM-WINTER ENGINEERING.

THE passing season has been an unprecedented one of its kind, as it was the second warm and open winter in succession, and it has caused a widespread demand throughout the Eastern States for harvesting ice off ponds, lakes, and rivers that usually are not used to any extent for that purpose. In consequence there has been great speculation in ice cutting and in the building of houses in which to store it. As some of our readers may be interested in this subject, we will give a brief account of the construction of these temporary ice-houses, and of the methods of stacking ice.

To better understand the enormous quantity of ice that is required to be harvested each year, we have only to remember that the cities of New York and Brooklyn alone consume about 3,000,000 tons of ice per annum. This represents a stack of ice about 844 ft. high, covering an area 800 × 200 ft., or the size of a large city block. In a favorable season, the ice companies supplying these cities try to house an extra million tons. Last winter being warm, no extra supply was secured, and when the present winter opened the companies found themselves without any supply to start with.

About the beginning of February, the companies began to cut ice from foreign fields, and the fever of speculation soon spread to outsiders. A few had already commenced, and these few will find themselves extremely fortunate.

The regular system of cutting ice is too well known to describe here, and the temporary methods adopted this winter were made to conform to them as nearly as practicable.

The first thing to do is to secure a suitable site for the house. A piece of level ground should be chosen, with an ice field in front of it in good condition. Select a place where the current of the water is as little as possible, so as not to wear away the ice when the first thaw sets in; where the water is deep near the bank for loading the boats in summer, or, if the ice is to be shipped in cars, near the railroad; and, again, a place sheltered from the winds, otherwise, after the ice has been opened the whole field is liable to move, crack, and pile up during a storm, thus ruining any chances for further operations.

If the site is a side-hill, the ice is apt to slip on melting, and if there is much movement to the stack, it will tear the house apart, as it is not constructed to withstand any such pressure. The next step is to determine how large a house is to be erected, and this is governed by the number of tons of ice required. A ton of stacked ice is reckoned as representing 45 cubic feet of space when properly stowed. Having decided on the size of the house, the lumber has to be purchased. For a temporary house, where there is little or no prospect of selling the old lumber, the cheapest kind of pine or spruce is to be preferred. The house is made rectangular in form. A mud-sill is first laid on the surface of the ground which has been smoothed of all inequalities. This mud-sill can be made of 2-in. stuff or of two 1-in. planks laid with broken joints. On this is erected a system of studs spaced about 2 ft. 6 in. in the clear. This will allow for the paper to be put on afterward.

These studs should be made of pieces 2 × 6 in. or 2 × 7 in. and 16 ft. long, which can be spliced so as to give any desired height to the house. These studs should be ceiled on the inside with planks laid horizontally, and this planking should be kept always higher than the pile of ice, so as to protect the edges from the wind and sun. Through the length of the building should be run a row of studs, spaced 5 ft. apart, dividing the house into rooms 25 ft. wide. This is for the purpose of supporting the roof, of which we will speak later. The ceiling or boarding can be made of 1-in. stuff, and the chief consideration to be observed is that it should be laid with as few cracks as possible, so as to keep the air from entering the house. Poles are sometimes used for studs, but they are not as good as squared stuff, since the planking cannot be put on so smoothly.

We now come to the inclines or slides. As the ice is usually plowed into cakes 32 in. long by 22 in. wide, a runway of 28 in. in the clear, allowing the cakes to go up lengthwise, will give very good results. These runways can be made as follows: For side pieces use 2 × 6 in. 8 ft. long. Thus 16 ft. stuff will cut into two pieces, with no waste. Set them up edgewise and fasten across the bottoms with ⅝-in. carriage-bolts, three strips 1½ × 3 in. On these lay longitudinally and equally spaced strips 1 in. × 3 in., on which the cakes can slide. These slides are joined by pins and eyes, made by the blacksmith, and the whole supported by a trestle. The bents of this trestle can be made of 2 × 6 in. posts, spliced if necessary, and diago-

nally braced by 1 × 8 in. planks. This cross-bracing should be put in every bent, but if the ground is firm it is only necessary to longitudinally cross-brace every other bent. These bents should be spaced about 10 ft. apart and rest upon a plank for a mud-sill.

The grade depends largely on the site chosen, but the incline should be as short as convenient, care being used not to make it too steep. These inclines should be erected so as to connect with the ends of the house and not enter on the face, as it is much more convenient to raise the slides and to handle the ice in stowing. In turning a corner to enter the house, an iron band, 3 in. × ½ in., is fastened to the outside piece of the slide and bent to conform to the arc required. On each side of the slide a pathway is made 2 ft. wide, with cleats nailed at convenient spaces, so that a man can easily walk up and down. The ice is hauled up these inclines by ropes operated by horses. The shore end of the rope has an ordinary hook spliced on, which will engage a ring on the whiffle-tree of the team, and can be easily hooked or unhooked by the driver. The rope then passes through blocks and down the slide. To the lower end is fastened a crab, which can be made of a piece of hard wood 3½ or 4 in. wide and 25 in. long, having three spikes or screws driven through it to catch the ice. A better crab is made out of a bar of iron bent so as to have two prongs that will hold the ice. A train of from 4 to 7 cakes of ice is pushed to the foot of the incline ; this is about all one team can draw up the average incline, unless it is very short and the ice is very thin. The crab being placed so as to engage the last cake, the man standing on the top of the incline gives the signal to the team, and the ice is pulled up until the top of the slide is reached, whence the ice runs by gravity down a reverse incline, around a bend and into the house. One man comes up the incline with the ice and carries the crab back, walking on the pathway at the side. Two ropes are operated on one slide, and if there are no delays in the field they will require three teams. A slide such as this, with two ropes, three teams, and about 150 ft. long, will elevate from 200 to 300 tons per day of 10 hours' work, if the men are accustomed to it. An endless rope can be operated, but for temporary houses they generally give trouble, and the simplest devices, although, perhaps, not the most economical, prove the best in the end.

When the ice reaches the house it is stacked, as it is called, on the ground, and in even and regular layers, placing the length of the cakes one way on the first course, and at right angles in the next, so as to break joints and bind the mass together. A space from 2½ to 3 in. should always be left around the cakes, so that a bar can be passed between them to pry them loose in the summer.

As the ice pile increases in height, the carpenters must keep raising the boarding on the studding. No scaffolding is needed, as the ice forms a working platform itself. Sometimes the ice is packed with hay. In this case a space about 12 to 14 in. wide is left all around between the ice and the sides of the house, and hay is packed in this. On the outside of the boarding and between the studs paper sheathing is nailed on with lathes. The studs should be so spaced as to allow for a strip of paper to be put on between them, leaving about 1 in. to turn up on each side for a joint.

If the hay packing is good and the papering well done, it is not necessary to put on any outside boarding, although it would greatly improve the house. A better and more permanent method is to leave an air space of about 3 in. between the ice and the inside boarding. This boarding is put on the same as before and papered. Then paper is laid in horizontal strips across the house, and tacked to the outside of the studs, and over this again a second boarding is put on. This arrangement makes the house very tight, and allows two distinct air spaces. If the paper is put on the inside of the inner boarding, it is too apt to become torn, as it must be put on while the men are working.

As the walls of the house are built up, it is well to put ties across made of 1 × 8 in. stuff nailed to the outside studs and also to the central row or rows of roofing studs. These ties being set up edgewise can pass between the cakes of ice. The advantage of having the house divided into rooms, is that one room can be filled at a time, and in case of a thaw or breaking up of the ice field, the ice already cut is stacked in a compact pile and not spread out over a large area of little depth. It is best, but not necessary, to board up between every two rooms, as this makes it better during the summer, when the ice is being removed, as only one compartment is disturbed at a time. On top of the ice a layer of hay should be placed to a depth of 12 to 18 in. Straw should not be used, as it is liable to stain the ice.

The walls of the house should be carried up 3 ft. above the top of the ice. As the rooms are 25 ft. wide, 2 in. × 6 in. stuff, 16 ft. long, will make very good rafters and allow sufficient pitch. The roof is boarded, but the top ends of the gables are left open for ventilation. Between the gables a gutter is made by laying a strip of tarred sheathing paper, and painting with a coating of melted pitch. If for roofing lumber cheap material has been bought, so that the joints cannot be made tight, it can be papered with the same sheathing as the sides.

It will not be necessary to describe the ice field or the methods of working, but there is one point not often understood. In laying out the field, it is always advisable, other things being equal, to work from the outside toward the house, as this will always leave an undisturbed stretch of ice from the bank out to the working cutting, for the passage of the men and horses, and the canal has also firm ice on each side for the men to walk back and forth in towing the ice to the foot of the slides.

Ice stacked in such a temporary house will suffer from shrinkage, varying with the workmanship, from 15 to 40 per cent., but such a house answers very well the purposes for which it is designed.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

V. PETROLEUM PRODUCTS.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page 126.*)

THE discovery of petroleum certainly introduced marvellous changes in the oils used by railroad companies. The animal and vegetable oils which were almost exclusively used 20 or 25 years ago, as has already been remarked, have been largely displaced by the products of the refining and distillation of petroleum, and this encroachment of the petroleum products is not only in the field of burning oils, but also in the field of lubricating oils. There is scarcely any animal or vegetable oil used alone in either of these two fields, at the present time, so far as our knowledge goes. It is, of course, natural that this should be so, as the prices of the petroleum products, by the constant developments of the enormous petroleum industry have constantly diminished, while the animal and vegetable oils have in comparison been held at very much higher prices.

It is probably well known that petroleum, as it comes

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the JOURNAL for December, is on the Work of the Chemist on a Railroad; No. II, in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number are on Lard Oil. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION of special value in indicating the true character of the materials they must use and buy.

from the ground, is a mixture of hydrocarbons, which differ from each other, so far as their physical properties go, principally in their boiling points and densities ; also that the crude oils from different regions of the country differ from each other quite considerably. In general, perhaps the best conception of the crude oil may be obtained by conceiving it to be like a right-angled triangle, the base of which represents the different chemical bodies which go to make up the oil, the perpendicular of which represents the successive temperatures at which the different constituents boil, and also the increase in specific gravity, which is characteristic of the different constituents, and the hypothenuse of which represents the boiling points and densities. Of course each region has its own characteristic triangle representing the oil, and it is also possible that the chemical bodies in the oils from the different regions are not entirely the same.

The composition of the crude oil being, as has been stated, a series of chemical bodies differing in boiling points, it is, of course, natural that the attempt to separate these different bodies should be by distillation, and accordingly, so far as we know, the first step in pretty nearly all refining of petroleum, after allowing the oil to settle for a while, is to put it into a still. Heat being applied, of course the constituents of the lower boiling point come off first. In general, we believe the condensed liquid is called "benzine," until the gravity reaches something like 60° or 65° Beaume's scale. Then comes, in general, the 110° fire-test oil, then the 150° fire-test oil, or higher fire-test oil, and still later the 300° fire-test oil. If the distillation is carried far enough nothing but tar remains in the still. If the distillation is stopped at the proper time, lubricating oil may remain in the still. Of course there are many modifications and characteristic methods of practice, which it would be inapplicable for us to give in detail, since we only care for general ideas as to the sources of the oils, which will be described later.

All the products of distillation as they come over are more or less contaminated with the heavier parts, and are more or less discolored from the presence of some of the tarry matters, which are either mechanically carried along or pass over in regular distillation. It is customary, we believe, to remove most of the color and tarry matters by treatment with oil of vitriol, which seems to have the power of combining chemically with the tarry matters and precipitating them to the bottom of the tank. Also some of the oils, especially the lubricating oils, are changed in color, and improved very much in appearance by filtering through bone black. The gasoline of the market is usually made by redistillation of the benzine, using vacuum, and, if we are rightly informed, in many of the best distilleries, most of the distillation throughout is carried on under the influence of vacuum. The paraffine oil, so called, we believe, is usually made by taking the tar, putting it into a smaller still, and subjecting it to distillation at considerably higher temperature, the distillation being practically carried to dryness, so that what is left in the still when the operation is complete is practically coke. This distillation may be repeated, if necessary, and then the product is paraffine wax and paraffine oil. The wax is usually separated from the oil by chilling and pressure in the same way that lard oil is separated from lard. A subsequent treatment of the oil with oil of vitriol improves the color very greatly, and gives, as will be described later, a very valuable lubricating oil.

Of all the enormous number of petroleum products which are now on the market, railroad companies commonly use five, we think, for lubrication and burning, and a sixth for burning is coming into use with the growth of the carburetter system of car lighting. The five are, 150° fire-test or headlight oil, 300° fire-test or car-lamp oil, paraffine oil for lubrication, well oil for lubrication, and 500° fire-test oil as a basis of cylinder lubricant. The sixth product, which seems to be coming into use, is gasoline. Of course, also, more or less benzine is used for cleaning and as solvent. Of these petroleum products specifications have been prepared for five ; the question of specifications for gasoline is yet under consideration, and it seems probable that within a few months possibly specifications for this material will be issued. The grade of benzine used is ordinary 66° gravity Beaume's scale, and the purpose for which it is used, requires no special protection or guarantees.

The specifications for petroleum products have been revised two or three times during the last 12 years, as the growth in knowledge of these products has increased, and as the necessity for protecting the interests of the Railroad Company have demanded new tests. The following is the latest revision of the specifications for petroleum products on the Pennsylvania Railroad, dated, as will be observed, September, 1889:

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Petroleum Products.

Five different grades of petroleum products will be used.

The materials desired under this specification are the products of the distillation and refining of petroleum unmixed with any other substances, and conforming to the detail specifications below. Products having very offensive odor, or being mixed with other oils, will not be accepted. Shipments must be made as soon as possible after the order is received. All shipments received at any place on or after October 1, must show the proper cold test, and all received on or after May 1, must show the proper flash point, and will be rejected if they fail, even though the order did not call for winter and summer oil, respectively, unless it can be shown that the shipments have been more than a week in transit. No preliminary examination of samples will be required, but a limited amount of special preliminary examination will be made on the request of the Purchasing Agent, for use of parties desiring the information. When a shipment is received, a single sample will be taken at random and subjected to test, and the shipment will be accepted or rejected on this sample. If rejected, it will be returned at the shippers' expense.

The following detail specifications will be enforced :

150° FIRE-TEST OIL.

This grade of oil will not be accepted if sample :

1. Is not "water white" in color.
2. Flashes below 130° Fahrenheit.
3. Burns below 151° Fahrenheit.
4. Is cloudy, or shipment has cloudy barrels when received, from the presence of glue or suspended matter.
5. Becomes opaque, or shows cloud when the sample has been 10 minutes at a temperature of 0° Fahrenheit.

The flashing and burning points are determined by heating the oil in an open vessel, not less than 12° per minute, and applying the test flame every 7°, beginning at 123° Fahrenheit. The cold test may be conveniently made by having an ounce of the oil in a four-ounce sample bottle, with a thermometer suspended in the oil, and exposing this to a freezing mixture of ice and salt. It is advisable to stir with the thermometer while the oil is cooling. The oil must remain transparent in the freezing mixture 10 minutes after it has cooled to zero.

300° FIRE-TEST OIL.

This grade of oil will not be accepted if sample :

1. Is not "water white" in color.
2. Flashes below 249° Fahrenheit.
3. Burns below 298° Fahrenheit.
4. Is cloudy, or shipment has cloudy barrels when received, from the presence of glue or suspended matter.
5. Becomes opaque, or shows cloud when the sample has been 10 minutes at a temperature of 32° Fahrenheit.

The flashing and burning points are determined the same as for 150° fire-test oil, except that the oil is heated 15° per minute, test flame being applied first at 242° Fahrenheit. The cold test is made the same as above, except that ice and water are used.

PARAFFINE OIL.

This grade of oil will not be accepted if the sample :

1. Is other than pale lemon color.
2. Flashes below 249° Fahrenheit.
3. Shows viscosity less than 40 seconds or more than 65 seconds when tested as described under "well oil" at 100° Fahrenheit throughout the year.
4. Has gravity at 60° Fahrenheit, below 24° Beaume, or above 29° Beaume.
5. From October 1 to May 1 has a cold test above 10° Fahrenheit.

Smith's Ferry oil may be used interchangeably with paraffine oil, but viscosity and cold test must be same as for well oil,

and gravity at 60° Fahrenheit from 33 to 35° Beaume. It is not expected that Smith's Ferry oil can be used in winter.

The flashing point is determined same as for 300° fire-test oil. The cold test is determined as follows: A couple of ounces of oil is put in a four-ounce sample bottle, and a thermometer placed in it. The oil is then frozen, a freezing mixture of ice and salt being used if necessary. When the oil has become hard, the bottle is removed from the freezing mixture and the frozen oil allowed to soften, being stirred and thoroughly mixed at the same time by means of the thermometer, until the mass will run from one end of the bottle to the other. The reading of the thermometer when this is the case, is regarded as the cold test of the oil.

WELL OIL.

This grade of oil will not be accepted if the sample:

1. Flashes, from May 1 to October 1, below 249° Fahrenheit, or from October 1 to May 1 below 200° Fahrenheit.
2. Has a gravity at 60° Fahrenheit, below 28° Beaume, or above 30°.
3. From October 1 to May 1 has a cold test above 10° Fahrenheit.
4. Shows any precipitation in 10 minutes when 5 cubic centimeters are mixed with 95 cubic centimeters of 88° gasoline.
5. Shows a viscosity less than 55 seconds, or more than 100 seconds, when tested as described below. From October 1 to May 1, test must be made at 100° Fahrenheit, and from May 1 to October 1 at 110° Fahrenheit.

For summer oil the flashing point is determined the same as for paraffine oil; and for winter oil the same, except that the test flame is applied first at 193° Fahrenheit. The cold test is made the same as for paraffine oil.

The precipitation test is to exclude tarry and suspended matter. It is easiest made by putting 5 cubic centimeters of the oil in a 100 cubic centimeter graduate, then filling to the mark with gasoline and thoroughly shaking.

The viscosity test is made as follows: A 100 cubic centimeter pipette of the long bulb form, is regraduated to hold just 100 cubic centimeters to the bottom of the bulb. The size of the aperture at the bottom is then made such that 100 cubic centimeters of water at 100° Fahrenheit will run out the pipette down to the bottom of the bulb in 34 seconds. Pipettes with bulbs varying from 1⅜ in. to 1½ in. in diameter outside, and about 4½ in. long give almost exactly the same results, provided the aperture at the bottom is the proper size. The pipette being obtained, the oil sample is heated to the required temperature, care being taken to have it uniformly heated, and then is drawn up into the pipette to the proper mark. The time occupied by the oil in running out, down to the bottom of the bulb, gives the test figures. A stop watch is convenient, but not essential in making the test. The temperature of the room affects the test a little. The limiting figures were obtained in a room at from 70° to 80° Fahrenheit. It will not usually be possible to make duplicate tests without readjustment of the temperature of the oil. Bullock & Crenshaw, 528 Arch Street, Philadelphia, can furnish the pipettes for making viscosity test. They should be ordered as "P. R. R. Viscosity Pipettes."

500° FIRE-TEST OIL.

This grade of oil will not be accepted if sample:

1. Flashes below 445° Fahrenheit.
2. Shows precipitation with gasoline when tested as described for well oil.

The flashing point is determined the same as for well oil, except that the test flame is applied first at 438° Fahrenheit.

THEODORE N. ELY,
General Superintendent Motive Power.

ALTOONA, PA., September 14, 1889.

The petroleum products being, as has already been described, the result of distillation, it is natural that the tests applied to determine the quality should be those having relation to the boiling points and densities. It will be observed that of the five petroleum products all of them have the flashing point taken and some of them the burning point. Much has been written and a large amount of experimentation has taken place with regard to the methods of taking flashing and burning points. In the burning oils, of course, the object of the determination of flashing and burning points is to secure an oil that is safe to use. In the lubricating oils the object of the determination of the flashing and burning points is to exclude those constituents which are poor lubricants. Those parts of the petroleum which are low in flashing point are so extremely limpid that they are practically of no value as lubricants with any pressures with which railroads have to do.

With regard to the burning oils we are hardly prepared to say that we think the method of taking the flashing and burning points which we commonly use, and which with more or less modifications is in common use everywhere, gives a perfectly safe oil, although it should be stated that with most lamp constructions which are in common use on railroads, an experience of now nearly 15 years shows that with oils which pass the tests given in the Pennsylvania Railroad specifications, explosions or accidents due to the oil almost never occur. In the two or three cases which have occurred some peculiarity in the use of the oil accounted for the accident. In one case a lamp was put behind a stove and the temperature of the oil became very high. In another case of headlight oil the lamp was so located that heat from the smoke-box heated the oil far above any safe limit of temperature. Notwithstanding this immunity from accidents, we are inclined to confess that the matter of the safety of the oil is more a question of the appliances used in burning the oil than the fact that the oil is perfectly safe to use. Moreover, interesting experiments were made a number of years ago by the Downer people, the results of which seemed to show that any lamp using an oil less than 300° fire-test, which lamp was perhaps not over half full of oil, might be in condition to explode almost any time after it had been burning for an hour or so, and apparently the reason why there were so few accidents with petroleum products is that the lamps are so constructed that the flame does not get to the space above the oil inside the lamp. Without going into minute details concerning these experiments, it may be stated that lamps were filled half full with different oils, and in place of the burner a hollow stopper, with a flap-valve opening downward, was put in each lamp, retained simply by friction alone. On allowing the lamp to stand even in the temperature of an ordinary room, and then slipping a lighted match down through the hollow stopper, an explosion results which closes the flap-valve and blows the stopper out. The experiments were varied likewise by having a lamp fitted with an electrical device which would fire the explosive mixture above the oil and blow the stopper out. The explanation of why lamps are in an explosive condition under the circumstances described, is perhaps not at all difficult to comprehend. As has already been described all the petroleum products are mixtures of hydrocarbons of different boiling points and densities, and the method of separation of these different constituents by distillation makes each resulting product have some of the higher and some of the lower of these constituents. For example, 150° fire-test oil is not exclusively a hydrocarbon which distills at a certain temperature, but a mixture of hydrocarbons of boiling points above and below the temperature corresponding to that at which most of the oil comes over from the still; in other words, ordinary 150° fire-test oil has some light oil in it and some heavier oil in it. This being granted, if the oil stands, as in a lamp half full, the tendency of the lighter parts, especially as the temperature goes up, is to separate from the mass of the oil and become a vapor mixed with the air in the lamp above the oil. If the proportions of air and oil vapor are right, this mixture is an explosive one, and, as stated above, the experiments of the Downer people seemed to indicate quite clearly that, with any of the marketable oils less than 300° fire-test, oil lamps, especially in warm weather, might be in a condition to explode. No oil is used, at least on the Pennsylvania Railroad, that is less than 150° fire-test, and if, as the experiments indicate, this oil, as commonly used in lamps, may be attended with some danger, still more so are the 110° fire-test oils known in the market as ordinary kerosene. Notwithstanding this difficulty, the experience of a number of years in using 150° fire-test oil has been so satisfactory, probably due, as stated above, largely to the appliances in which the oil is used, that very little anxiety is felt in using an oil which fairly passes the requirements of the specifications given above, and accordingly its use is continued in many places. In a subsequent article, however, it will be seen that no 150° oil even is used where it can have any chance to affect the safety of the passengers, with the bare exception of out-door lamps at small stations for lighting up the platform. It should also be stated that strenuous and earnest study is being

put on the question of using only 300° fire-test oil in all places as a burning oil. The appliances for doing this have not yet been fully developed, but very promising results have been obtained, and it is hoped that within a year or two no oil will be burned anywhere on the Pennsylvania Railroad which has a lower fire-test than that given in the specifications for 300° fire-test oil.

A small volume could be written on the method of making fire-tests, especially of the burning oils, and it should be confessed at the outset that the number of variables which affect the flashing and burning points of a good sample of oil are so great that it is not at all uncommon for duplicate samples out of the same can to give different results. In general the methods in use may be divided into two classes, namely, closed-cup and open-cup testing. Both of the methods have their advantages and apparently both their disadvantages. It is probable that the closed-cup method gives results which are the safest guide. On the other hand, the closed-cup method is very slow, and where a large amount of work is to be done is hardly available. We use exclusively the open-cup method of testing. The apparatus which we make use of is an ordinary small iron cup sand-bath placed above a Bunsen burner, which plays directly against the pan of the sand-bath and heats the sand. In the sand-bath an ordinary porcelain dish, such as are commonly used in chemical laboratories, about 2⅝ in. diameter inside and about 1 in. deep inside, is placed. This is filled to within ¼ in. of the top with the oil to be tested, the amount of oil under test being about one fluid ounce. A thermometer is suspended in about the center of the surface of the oil, so that the bulb is fairly immersed in the oil, but does not touch the bottom of the dish. As a test flame we use a very small gas-jet, about as big as the bead of flame on the end of a burning string. We usually draw out a glass tube to a fine aperture and allow the gas to pass through this aperture until we get the size of flame mentioned.

In our experience with open-cup testing, the following variables affect the flashing and burning points: First, rate of heating; second, size and depth of the cup used; third, amount of oil used; fourth, the thermometer; fifth, distance of the test flame from the oil; sixth, the size of the test flame; seventh, the length of time the test flame is held above the surface of the oil; eighth, the place where the test flame is held; ninth, how often the test flame is applied, and tenth, surrounding conditions and peculiarities of the apparatus and manipulator.

In view of this large number of variables, it is, perhaps, not surprising that there should be so much discrepancy in the fire-tests made by different parties, nor indeed surprising that duplicate tests out of the same can should not give exactly the same results. In our experience the most important variable is the rate of heating. It is entirely possible to take a sample of oil and get a higher fire-test by from 5° to 10°, by making the rate of heating very slow, over what would be obtained if the rate of heating was more rapid, and it is, perhaps, not difficult to see why this is so. The flashing point is in reality that temperature at which enough oil vapor escapes from the oil under test to mix with the air just above the surface of the oil and form a combustible or slightly explosive mixture. The burning point is the temperature at which the evolution of vapor from the surface of the oil is sufficiently rapid to maintain a flame. Still further, it is quite clear that as the oil vapor escapes from the surface of the oil it has a tendency to dissipate itself into the surrounding air. If, now, the rate at which the oil vapor is driven out of the oil is very slow, the dissipation may be almost proportional to the rate at which the vapor escapes from the oil, and consequently no accumulation of oil vapor sufficient to form a combustible mixture would take place. Under these conditions the oil would show a high fire-test. On the other hand, if the heating is more rapid, so that the evolution of oil vapor is more rapid, the flashing point will be considerably lower. So important do we regard this variable of rate of heating that we especially specify it in our specifications. It will be observed that for the 150° oil we raise the temperature of the oil not less than 12° a minute, and for all the other oils we raise the temperature not less than 15° per minute. Some of the petroleum refiners have regarded this as a little severe, and we find many of the so-called 150° oils of the market which will not stand test at this comparatively rapid heating. Our interpretation of the value of this test is that it is designed to protect the consumers of oil from using dangerous material, and not that it was designed to enable manufacturers to sell an oil of lower fire test. We have, accordingly, interpreted every one of the variables, especially in testing 150° oil, against the manufacturers. We conceive as long as this is thoroughly understood, that it is perfectly fair, and as long as we do not object to paying the price which is determined by open competition, in order to get the oil which we want, we do not see anything wrong in being strenuous in regard to the testing of these kinds of oils.

The size and depth of the cup affects the fire test in this; if the same amount of oil is in a large shallow cup, the dissipation of the oil vapor into the surrounding air is more rapid than if it is in a smaller sized deep cup, and the dissipation of the oil vapor being a function of the flashing and burning points, it is plain to be seen that these two variables would affect the test. Also whether the cup is filled nearly full or partly full affects the fire test. Quite elaborate experiments have been made by the German experimenters, on a means of getting duplicate tests to within one degree on the same sample of oil, and a deep cylinder filled about half full of oil has been found to give the nearest to uniform results of any method of testing. It is plain to be seen why this should be so, since that portion of the cylinder which is above the surface of the oil prevents the dissipation of the vapor, and, consequently, if the rate of heating and the other variables are uniform, duplicate tests on the same sample would have a much greater tendency to be the same.

The amount of oil affects the test, as is plain to be seen by virtue of the amount of vapor which is generated. With a large amount of oil, the same rate of heating and other variables uniform, a much larger amount of vapor will be generated in the same time than with a small amount of oil, and, consequently, the temperature at which the combustible mixture will be formed above the surface of the oil will be different than if a smaller amount of oil was used, since the rate of the dissipation of the vapor, as has already been stated, is a function of the test. It is obvious that if a large amount of vapor is furnished, the combustible or semi-explosive mixture will be sooner reached than if a smaller amount of vapor is furnished. The effect of the larger amount of oil is to make the test a little more severe on the oil.

The thermometer affects the test somewhat more in its unreliability than in any other way, it being a very common experience with thermometers that they are from 1° to 3° out in their readings, and also that a thermometer which has been used for some time, and especially if the same thermometer has been used to make high fire tests, as well as low, gives readings which are unreliable. We usually use what are known as the best chemical thermometers obtainable from the ordinary chemical supply dealers and discontinue their use after a few months.

The distance of the test flame from the surface of the oil makes quite a difference in the fire test. If the test flame is put down to within ⅛ in. of the oil the flash and burn will be obtained considerably sooner than if the test flame is held ½ in. or ⅝ in. above the surface of the oil. This is, of course, readily understood on the hypothesis previously suggested, that the flash and burn are simply mixtures of air and oil vapor, and it is obvious that the mixture of air and oil vapor, especially in the flashing point, would sooner reach the combustible point at ⅛ in. above the oil than ⅝ in. above the oil. We usually hold the test flame about ¼ in. above the oil.

The size of the test flame has an influence in its effect on the generation of vapor from the oil. A bead of flame one-half as large in diameter as a lead-pencil and maybe ¼ in. long, will give a different result from a test flame as large as a lead-pencil and ⅝ in. long. This is especially noticeable in burning point, not so much in flashing point.

The length of time that the test flame is held to the oil also has an influence in the effect of the flame on the oil. This is quite clear, we think, without explanation. If the flame is held within ¼ in. of the oil for some seconds it

will have a tendency to heat the oil at that point and thus cause the generation of vapor from the oil with a consequently lower test than if the test flame is simply applied and taken away again. We usually hold the test flame near the surface of the oil not more than perhaps a second. We do not, as is customary with many professional testers, pass the flame rapidly over the surface of the oil about ½ in. away from it. We really do not have much objection to this method if the flame is passed across the dish, but our custom has been usually to hold the flame for at least a second about ½ in. from the surface of the oil.

The place on the surface of the oil where the test flame is applied is a matter of considerable importance. If the test flame is held near the edge of the dish, a flash will be obtained at a number of degrees lower temperature than if the flame is adroitly passed down near the thermometer to within ½ in. of the surface of the oil and as adroitly pulled out again. It is obvious why this should be so. At the edge of the dish the oil vapor and the air have the best chance to mix, while in the center of the dish, near the thermometer, the material may be largely oil vapor. The flame being held at the edge of the dish, where the mixture of oil vapor and air has the greatest probability of being combustible, we get a little severer test on the oil, perhaps, but we think one which protects the interests of the consumer better. A number of years ago, in the case of a dispute, the legalized oil-tester of Pennsylvania came to Altoona to test a shipment of oil which we had rejected. We furnished him the proper appliances, and in every respect he did the same as we do, except we were inclined to heat the oil more rapidly than he liked, and also we applied the test flame at the edge of the dish while he applied it alongside of the thermometer. This single variable of where the test flame was applied caused the rejection of this shipment, and he claimed his test was valid because the law of the State under which he was working did not specify where the flame should be applied. On the other hand, we claimed that the law of the State was designed to protect the consumer and not furnish facilities to dealers to sell low fire-test oil, and accordingly, since the law was silent, we were entirely at liberty to apply the test flame wherever we desired. Of course in this case no legal questions were involved, since the oil was bought on specifications, and our view of the case was sustained by the authorities. We are likewise inclined to think this view of the case would be sustained by the courts in case the question should go before them. In our view the place where the test flame is held in open-cup testing is the next most important variable after the rate of heating.

How often the test flame is applied affects the test of a very sensitive oil apparently by the influence of the test flame on the surface of the oil. If the test flame is applied every degree a considerably lower fire test will be obtained than if the test flame is applied as is our custom every 7°. It is plain to be seen that the influence of the heat of the test flame on a very sensitive oil would be considerable.

The surrounding conditions have some influence on the test of an oil, notably, the barometric pressure being quite low, the escape of the vapor from the surface of the oil is more easy than with a higher barometric pressure, and in a very sensitive oil this undoubtedly makes some difference. We had a case once in which we were utterly unable to account for the difference obtained in testing the same sample of oil with the same apparatus and same manipulator on several successive days except by the barometric pressure. Furthermore, currents of air passing over the dish are especially important surrounding conditions. It is very clear why this should be so. If the vapor is carried off by a current of air as fast as it is generated, it is obvious that the fire test will be considerably higher than if the vapor which comes out of the oil is allowed to accumulate over its surface. It is not always pleasant to make fire tests of oils in a closed room, but we are very careful in our work to have no currents of air to assist the dissipation of the oil vapor which is set free from the surface of the oil. It is also claimed by some experimenters that two pieces of apparatus for taking fire tests, which are made absolutely alike, as near as possible, will not necessarily give the same results. We have never experimented much in this field, but are inclined to think the difference due to the apparatus would not be very large. Also we find that with the same apparatus two manipulators may not necessarily secure the same result from the same oil, although they attempt to make the manipulation as near as possible alike.

In the next article we will continue the discussion of the testing of petroleum products, and if space permits, discuss briefly a few other oils which are or may be used by railroads. This will be followed by complete statements of how the various oils described in the previous articles are actually used on the Pennsylvania Railroad, including the formulas for the various mixtures, with notes drawn from the experience in the use of these oils during the last 15 years.

(TO BE CONTINUED.)

THE ESSENTIALS OF MECHANICAL DRAWING.

By M. N. Forney.

(*Continued from page* 137.)

CHAPTER II.

The Use and Care of Drawing Instruments.

THE DRAWING BOARD.

To the description of the drawing board, which has already been given, it should be added that no oil, paint, varnish, or polish of any kind should be applied to any part of it. The board, when in use, should be inclined like the lid of a desk, and elevated high enough, so that when the learner stands up he will not be obliged to bend over too much to reach the middle of the board. In drawing a draftsman has much greater freedom of movement when standing than he has if he is sitting down. All young draftsmen are therefore advised to discard seats while they are drawing. A stool or step, 7 or 8 in. high, is often a convenience to stand on while drawing on the upper part of the board. This step can be pushed under the table on which the board rests, when not in use.

Care should be taken that no indentations or holes of any kind—excepting those left by drawing tacks—are made in the board, as it is impossible to draw a true line over such places, and the points of dividers and compasses are liable to punch unsightly holes in the paper if there is an indentation below it.

The board should be placed with its left-hand edge next the window, so that the light will fall from that side, and it will be found that light from the upper part of a window will give greater distinctness to lines on the paper than that coming from the lower part. It is a good plan, therefore, to have the window-curtains in a drawing-room to roll up at the bottom of the window instead of the top. In the northern hemisphere a window facing north gives the best light to draw by, as there is no sunshine from that quarter.

PAPER.

The paper should be fastened to the board with a drawing tack in each corner. It should be smoothed down by passing the hand from the center of the sheet outward toward the corners, so as to stretch it as evenly as possible. Additional tacks may be placed between the corners if required.

Paper which is kept for use should always be laid flat and not kept in rolls. If it is kept rolled it will curl up on the board and is thus difficult to smooth down evenly. If it must be rolled for transportation, the roll should be of as large diameter as practicable, so as to curl up the paper as little as possible. The same remarks will apply to finished drawings.

T-SQUARES.

It is not very important that the back or stock of the T-square should be exactly square with the blade, although it is well to have it as near square as it can conveniently be made. The edge of the stock, which bears against the board, should be made perfectly straight, or very *slightly* concave. If either the edge of the board or that of the stock is convex, the latter is liable to rock against the board, and thus the edge of the T-square may not be parallel in different positions, which will lead to errors and inaccuracies in drawing. If either or both are very *slightly* concave the T-square will always bear against the board without any liability to rock.

The upper edge of the T-square, which is used in drawing, must be perfectly straight, or as nearly so as it can be made.

To true the edge of the blade, first plane it as straight as it

can be made "by the eye;" then lay it on a smooth piece of paper or board and draw a fine line with a hard, sharp-pointed pencil or the point of a knife along the edge to be trued. Then turn the blade upside down and see whether the edge coincides exactly with the line thus drawn. If it does the edge is true, if not the error must be corrected.

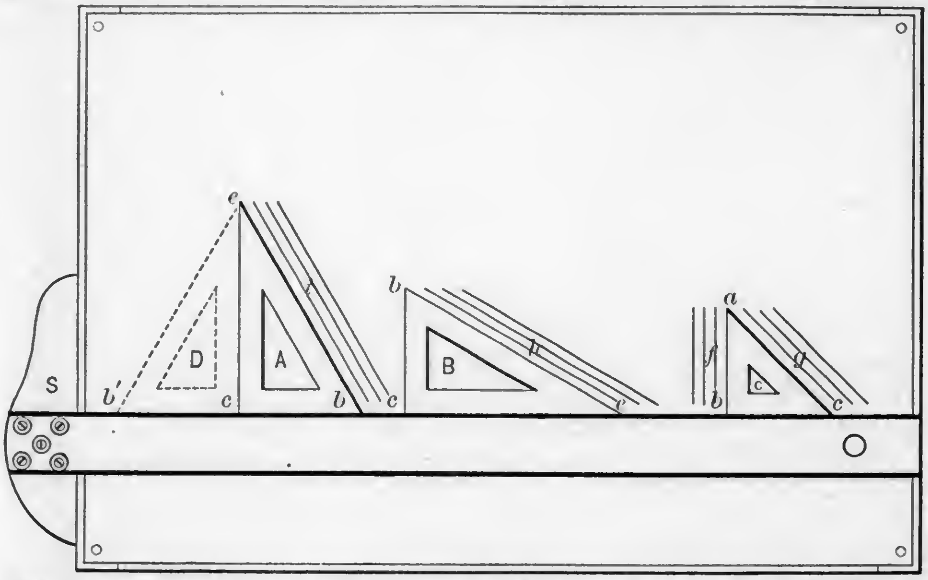
Another method is to place a straight-edge, which is supposed to be true, so that its edge and that of the blade coincide, and then hold them up to the light and see whether it shows between them. If one of them is slightly concave and the other convex, they may coincide so that the light will not show between them, yet neither will be straight. To get over this difficulty, a third straight-edge should be used to see whether the first and second both coincide with it. If they do they are all straight, and if they are not it will appear when the two, which are both either concave or convex, are brought into juxtaposition with each other.

Great care must be taken to protect the edge of the blade of the T-square from indentation or other injury, as the slightest notch or irregularity will be shown by every line that is drawn along the injured part of the blade. To protect it the T-square should always be hung up when not in use.

The edge of the blade should be square and not chamfered, or beveled, as it often is, as the square-edge gives much greater command over the position of the pen in inking drawings, and in drawing dotted lines the pen is apt to be lifted up above the edge of the blade if it is made too thin by beveling.

The T-square should be used with its stock, *S*, against the left-hand edge of the board, as shown in fig. 21, and all horizontal lines can be drawn with it. If it is used with its stock against the upper or lower edge of the board, unless the latter has been squared up recently it cannot be depended upon, and lines drawn from different edges of the board will not generally be found to be exactly at right angles or "square" with each other.

Fig. 21.



TRIANGLES.

It is of the utmost importance that the 90° angle of each of the triangles should be exactly "square." To ascertain whether it is square, place the triangle with its short side against the blade of the T-square, as shown at *A*, fig. 21, and draw a fine line along the side *e c*. Then, without moving the blade, turn the triangle over to the opposite side of the line, as indicated by the dotted lines at *D*, and then observe whether the side *e c* coincides exactly with the line which was drawn with the triangle in the first position. If the angle *e c b* is "square," the side *e c* when the triangle is in the opposite positions, will coincide exactly with this line.

The same directions which have been given with reference to having the edge of the T-square blade straight and preserving it from injury, will also apply to the triangles.

To draw a line perpendicular or square to the blade of the T-square, one of the triangles should be placed in contact with the blade of the T-square in either of the positions shown at *A*, *B*, or *C*, fig. 20. The stock of the T-square should be held firmly against the edge of the board with the left hand, and the triangle ought then to be pressed against the edge of the blade of the T-square, and the two must be securely held in that position. The line may then be drawn along the edges *e c*, *b c*, or *a b*, and it will then be perpendicular to any line drawn along the edge of the blade of the T-square, if its stock is securely held against the edge of the board when the line is drawn.

If the perpendicular line must be longer than the side of the triangle, then it should first be drawn as long as the triangle will permit, and the T-square can then be turned around and its blade laid so that its edge coincides with the line thus drawn, which can then be extended to the length required by drawing along the blade.

To draw two or more parallel perpendicular lines, as shown at *f*, the triangle *C* can be slid along the edge of the blade. To draw a line at an angle of 30° to a horizontal line, place the large triangle in the position shown at *B*, and draw along the edge *b c*. A line at an angle of 60° may be drawn by placing the triangle in the position shown at *A* or *D*, and drawing along *e b* or *e b'*, and one at 45° by placing the small triangle, as shown at *C*, and drawing along the side *a c*. To draw parallel lines at these angles, slide the triangles on the edges of the blade, and draw them as shown at *g h* and *i*.

DRAWING SCALE.

It would be desirable, if it were practicable, to make all drawings full size—and working drawings of machinery, when the parts are not too large, are usually made to that scale. The size of the objects to be represented is often so great though, that the drawings must be made smaller than full size. As beginners sometimes have difficulty in understanding how a reduced scale represents full sized dimensions, a little explanation may be needed. We may take, as an example, a locomotive driving-wheel of say 6 ft. diameter. If this were drawn full size the drawing would be over 6 ft. long and 6 ft. wide, which ordinarily would be inconvenient to handle. Therefore such drawings are often made to a scale of one-quarter of their full size. That is, any part of the wheel which is 1 in. long or wide is represented on the drawing as only $\frac{1}{4}$ in. long or wide. If it is 1 ft. long, it is only 3 in. on the drawing. This will be understood by referring to fig. 8,* which represents a two-foot rule one-quarter its full size. Now if we had a little rule of the size of the engraving, on which each inch was only $\frac{1}{4}$ in. and a foot only 3 in. long, then this would be a scale of quarter size, or of 3 in., equal to one foot. Drawing scales are graduated in a similar way, that is, the inches are $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, or $\frac{1}{16}$ in. long, and feet are 3, 2, $1\frac{1}{2}$, 1, $\frac{3}{4}$, $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{8}$, and $\frac{1}{16}$ in. long, and drawings made from them are said to be to a scale of 3 in., 1 in., $\frac{1}{8}$ in., etc., equal to a foot.

Drawing scales should be straight, or nearly so. If they are crooked they will not rest on the board steadily. The graduations, if examined with a magnifying glass, should not appear irregular or of varying size.

In laying down dimensions from a triangular scale the edge containing the scale to be used should be placed on the paper, and the measurements can then be marked either with the point of a pencil or pricked with the dividers. If the movable point shown at *A*, fig. 11,* is put into the pen-holder, fig. 12, it forms a convenient instrument for this purpose. Dimensions may be taken direct from the scale with a pair of dividers and transferred to the paper.

PENCIL.

All that need be observed with regard to pencils is that their points should be kept sharp. If they are made of the form of a chisel edge, as already remarked, they will remain sharp a longer time than if they are made round.

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* See March number of JOURNAL.

DIVIDERS.

As their name implies, the chief use of dividers is to *divide* spaces into equal parts. They are also used for laying off dimensions which are taken from the scale, or from some part of the drawing. Their points should be of exactly the same length; and kept as sharp as needle-points. If they are allowed to become dull, they are liable to punch large holes in the paper. The compasses, fig. 10*, can be used as dividers by removing the pen *B*, and substituting the point *A*, fig. 11*. The spring dividers, fig. 11 or fig. 18, are used for small dimensions, and the joint compasses, fig. 10, with the point *A*, or the dividers, fig. 17, are used for larger dimensions.

In using dividers a novice is very apt to take hold of the legs, thinking that it can thus be held more securely. At the very beginning a learner should accustom himself to handle dividers and compasses by the joint alone, using only the thumb and the first two fingers.

COMPASSES.

The compasses are used chiefly for drawing circles or parts of circles, either with a pencil or ink. The joint compasses, fig. 10*, is used for circles and curves of from ½ in. up to about 3½ in. radius, and the spring compasses for circles and curves of ½ in. radius and less. The beam-compasses, fig. 19*, is used when the radius is greater than 3½ in. To draw circles or curves with a pencil, the holder, shown at *C*, fig. 19, is inserted in any one of the instruments, and the pen *B*, fig. 10, may also be used in any of them for drawing with ink. The pencil-holder and pen are held in each of these instruments with a clamping screw, shown in the engravings. The shanks of the pen, pencil-holder, and point *A*, fig. 11, and the sockets to receive them are made slightly tapered, so that if the screws are properly adjusted, the pen-holder or point may be removed and replaced without moving the screws.

In using the compasses, fig. 10, it is desirable that the leg which has the needle-point should always be perpendicular to the drawing or surface of the board. If it stands at an inclination, the needle-point will make an objectionably large hole in the paper when the compasses are turned in drawing a circle. If the pen does not stand perpendicular to the paper, then only one of its nibs or points will touch the paper, and either it will not mark at all or the line drawn will be ragged and irregular. It is also desirable that the pencil should always be vertical to the paper when the compasses are used. For these reasons its legs are jointed, so that they may be bent inward in proportion as the compasses are extended, and thus they may always be kept in a vertical position.

In using the beam-compasses, fig. 19, wooden sticks or beams of different lengths can be made as required, and the fixed head *D* is then fastened to them by the set screw *E*. The movable head *F* is adjusted in any desired position by the screw *G*. As it is difficult to adjust the pen or pencil at *C* very precisely by the sliding head *F*, the pen and pencil are attached to a bent spring, *B*, and their position is then regulated exactly by the nut *A*.

The pencil-holder consists of a tube split through part of its length, with a ring to move up and down, by which the hexagon lead from an ordinary HHHHHH pencil can be used in it, and is securely held by the movable ring.

In using compasses, as well as dividers, they should be handled by the joint alone, and the learner should not take hold of the legs excepting, perhaps, to steady the movable one in drawing large circles. In drawing a circle "begin it at the lowest point, holding the joint of the compasses between the thumb and the middle finger, the index finger resting lightly against the left side of the joint. Turn the compasses *with* the clock, describing the left half of the circumference by rolling the joint between the thumb and second finger ; that finger can go no farther, but its place is then easily and naturally taken by the first finger, and the joint is rolled between it and the thumb until the circle is completed, by one continuous motion. This requires a little practice, but the trick, if it is once acquired, is never forgotten, and the instrument is at all times under perfect control, with no danger of altering the radius.

"In setting the compasses to draw a circle of a given diameter, it is not enough simply to open the legs to the required radius, for it seldom happens that this can be done with exactness ; two short arcs should be struck, on opposite sides of the center, and the scale applied to see that the *diameter* is correct." †

The needle-point of compasses should be slightly longer than the pen or pencil, for the reason that the point enters the paper more or less when the instrument is in use, and the point of the pen or pencil should then be of such a length as to just touch the surface of the paper.

PEN.

There is no instrument which will give the young draftsman so much trouble and perplexity as the drawing-pen, and there is none which requires so much skill and care to keep it in good condition. It consists of two blades, whose elasticity tends to separate the points, whose distance apart determines the width of the line which is drawn. They are adjusted by a screw, shown at *B*, fig. 10. The two blades should be made from a solid piece of steel cut apart. Pens are often made with one blade jointed, so that the two can be separated for convenience in cleaning, but the joint is liable to allow more or less lateral movement to one of the points. When this occurs the pen will not draw a smooth, sharp line, but the latter will be more or less ragged.

To draw a clear, distinct line the points should be rounded and sharp, but not keen enough to cut the paper, and they should be of exactly the same length. A fine oil-stone and a magnifying glass should be used in sharpening pens. To determine whether the points are of exactly the same length, hold the pen perpendicular to the surface of the left thumb-nail and make a mark on it with the points. If they are of the same length they will mark two lines on the nail, but if one is longer than the other it will make only one line. If that is the case, the points should be brought to the same length by a few light strokes on the oil-stone, while holding the pen vertically to its surface. If either of the points is dulled by this process, it must then be sharpened by rubbing its sides on the stone. Great care and delicacy are required in sharpening a pen and keeping it in good condition.

One important precaution which must be observed, in order to keep the pen in good condition, is that it should *always* be thoroughly cleaned after using it. The learner should preserve his worn-out linen pocket-handkerchiefs for this purpose. They have just the required softness and can be inserted between the points of the pens.

To charge a pen with ink, take a postal card and cut it into strips 3 in. long and ⅜ in. wide. Dip one end in the ink, which has been rubbed in a cup or saucer, and transfer that which adheres to the strip to the pen, by inserting the end of the strip between its points. By this means you avoid getting ink on the outside of the blades of the pen—as will be the case if it is dipped into the ink—which is quite certain to blot the paper.

It is essential that the pen should always be charged with fresh ink. After it has been in the pen for a few minutes it dries between the points and will not flow. When this occurs it should be cleaned and freshly charged. It is a good plan to keep a glass of water at hand, and in cleaning the pen first dip it into the water. This facilitates the removal of the dried ink.

The instruments which were illustrated in the March number of the JOURNAL are designed so that the same pen can be used for all of the compasses, and also for drawing straight lines by inserting it in a handle or holder shown in fig. 12.

In drawing straight lines, the pen should be held so as to be perpendicular with the surface of the paper, and the point nearest to the blade of the T-square, triangle, or straight-edge, which is used as a ruler, should bear against its upper edge. If it bears against the lower edge, the ink flowing from the pen is liable to come in contact with the ruler and blot the paper. When a pen will not mark satisfactorily, new beginners are apt to press it hard against the edge of the *T* square or triangle, and thus they press its points together, which prevents or obstructs the flow of the ink. The learner should aim to press the pen against the edge of the T-square or triangle only enough to keep it securely in contact and to prevent it from "running off the track." It will require some practice and patience to acquire the delicacy of touch and feeling to handle a pen satisfactorily.

INDIA INK.

All that need be observed in using India ink is that it be rubbed so as to be free from lumps. To do this dip your finger in a glass of water, and from the end of it drop eight or 10 drops of water into one of the ink saucers. Then rub the end of the stick of ink gently in the saucer until the liquid is dark black. To ascertain whether it is black enough, hold the saucer a little inclined for a few seconds. If the ink runs off of the bottom of the saucer so that the latter shows through the liquid, it is not dark enough, and more rubbing is required. If after rubbing the ink is lumpy, a cork or the end of the finger may be used to rub it to a condition of uniform consistency.

GENERAL REMARKS.

"In pencilling work be careful not to press too heavily on

* See March number.
† Practical Hints for Draftsmen, by Professor C. W. MacCord.

your pencil; the lines should be so lightly done that they can, if required, be easily rubbed out with india-rubber, without disturbing the grain on the surface of the paper. Draw all pencil lines past each other at angles and intersections; for as the edge of the rule partly obstructs your view of the line when

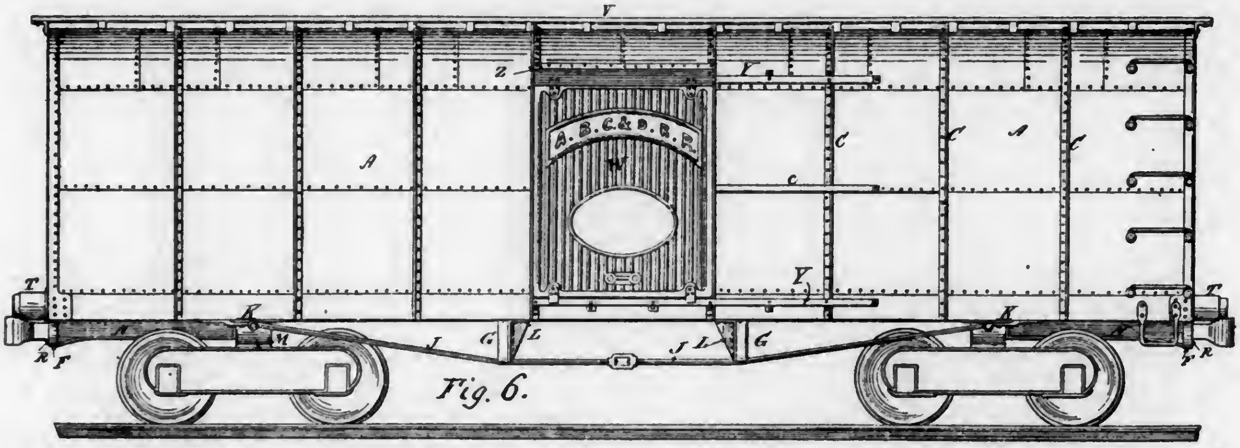


Fig. 6.

inking, you are liable to pass over the required point, which annoyance will be prevented by another pencil line crossing at the exact spot at which you are to stop." *

"Circles and circular arcs should, in general, be inked in before straight lines, as the latter may be more readily drawn to join the former than the former to the latter. When a number of circles are to be described from one center, the smaller should be inked first, while the center is in better condition." †

In drawing cleanliness is absolutely essential in order to good work. The hands, the instruments, the drawing board, the paper (and it may be added the conscience) should all be kept clean. A brush should always be at hand to clear away dust; and water, basin, soap, and towel are always needed. The drawing board ought always be covered when not in use. A sheet of any kind of paper is better than cloth for this purpose, because the latter lets the dust through; although a piece of oil or enamelled cloth is not open to this objection, and therefore makes an excellent cover. After being used for some time the T-square, triangles, scale, and drawing-board will become soiled. They should then be cleaned with a damp sponge and a little soap.

(TO BE CONTINUED.)

Recent Patents.

I.—HUGHES'S METALLIC RAILROAD CAR.

MR. EDWARD MACKENZIE HUGHES, of the Fox Solid Pressed Steel Company, of Chicago, has patented a metallic car illustrated by the engravings.

He describes his invention as follows:

Fig. 6 represents, generally, the body of the car, which has the general shape shown in section in fig. 7. Fig. 8 is a transverse section, and fig. 9 is a horizontal section of the end of the car. It is made of plates riveted together, as shown. The side-plates are flat, while the roof-plates are pressed to a curve, as shown. The plates of the sides and the ends of the car are lapped and riveted through an inside strip *B*. The carlings or supports for the sides and roof are shown at *C*, and are preferably made of a single piece carried from the side sills over the top of the car, as shown in fig. 7. These carlings may be of angle-steel riveted to the plates beneath. They are attached to the side sills by brackets, or in any suitable way.

The sills of the car *D* are made of channel-steel, and are attached at their ends by knee-pieces *E* to the end sills *F*.

The cross-ties *G* are made of pressed steel of the shape clearly indicated in fig. 7, and are shaped at the ends into descending brackets *H*, serving as king-posts or supports for the body truss-rods *J*, which are supported by the hinged connection from the side sills at *K*, as shown in fig. 6. These cross-ties may be braced by gusset-plates *L*, as shown in fig. 6, and upon these cross-ties *G* the longitudinal sills rest, as clearly shown in fig. 7.

The body-bolster *M* is made of pressed steel, and preferably has a center-plate pressed therein.

The structure of the bolster, transom, and truck may be of any form desired. The draw-bar is attached to the body-bolster by plates *N N*, fig. 8, which are preferably flanged and riveted to the body-bolster. They are bent to form recesses upon their facing sides to receive the box for the draw-head, and are closed below the draw-head by a perforated plate *P*, as shown in fig. 8. The end sill, which is made of pressed steel, has a projection and an opening for the passage of the draw-head. The draft-

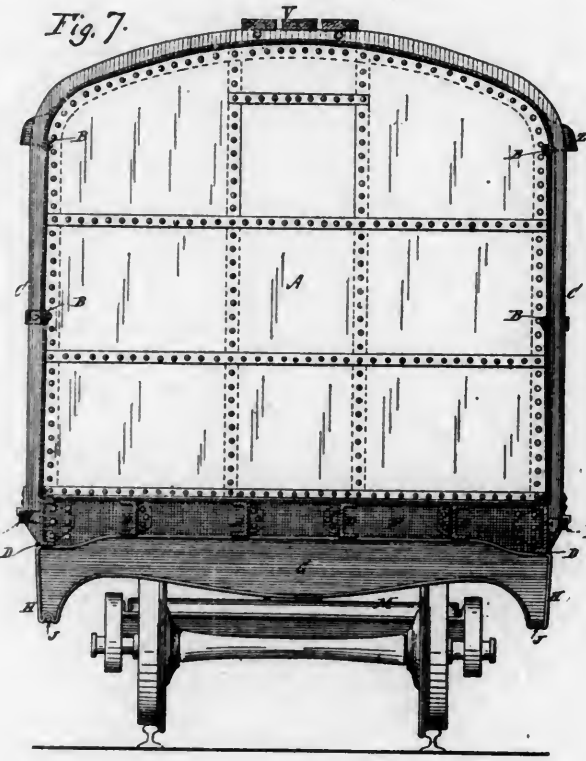


Fig. 7.

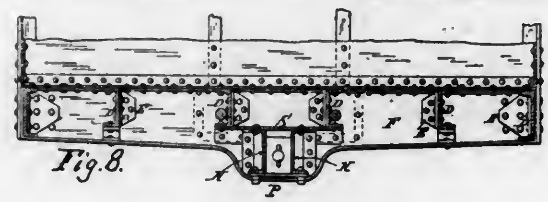


Fig. 8.

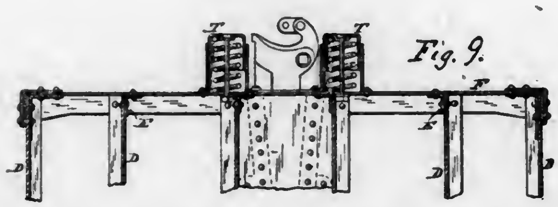


Fig. 9.

plates *N* are preferably attached at their upper ends to a plate *S*, riveted to the bottom of the center sills, as shown in fig. 8.

The buffers *T* are made of pressed-steel boxes fitting within

* Drawing for Machinists and Engineers, by Ellis A. Davidson.
† Engineer and Machinists' Drawing Book.

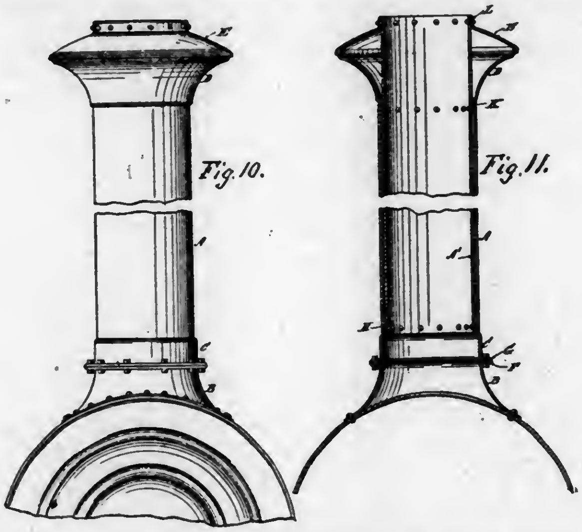
surrounding cylinders riveted to the end plates, as shown in fig. 9. They are, of course, provided with an interior spring, and their motion is limited by a longitudinal bolt.

A running plank V, fig. 7, may be provided on top of the car, and is intended to be the only wooden part of the structure, although an additional wooden roof may be employed.

The floor of the car consists of plates of metal riveted together, serving to brace and support the end sills and longitudinal sills. The structure is shown as applied to a freight-car; but it is in part applicable to passenger-cars.

II.—HUGHES'S SMOKE-STACK.

The inventor of the metallic car has also patented a smoke-stack made of pressed steel. It is shown in figs. 10 and 11.



It consists of two cylinders of metal A A', as indicated, between which the improved smoke-stack base and top are applied.

The smoke-stack base consists of two parts B C, which are formed of single pieces of steel pressed to a circular form, as indicated. The advantage of this arrangement is to insure tightness of fit between the parts which are pressed in dies, so as to make absolute contacts, and also to prevent any escape of the products of combustion or interference with the drafts. The part B is flanged outward into a bell shape, as indicated at the bottom, and cut away at the front and rear, so as to be shaped to the top of the boiler. It has likewise a flange F, as indicated, corresponding to a flange G of the part C. The part C is like-

Fig. 12.

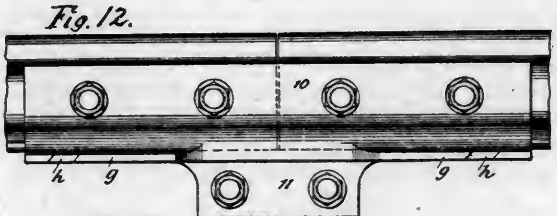
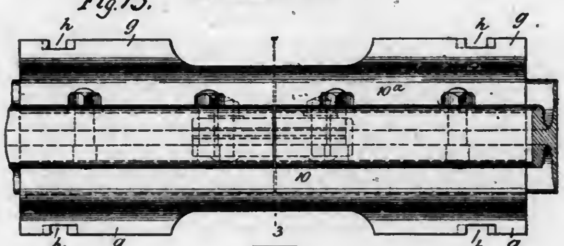
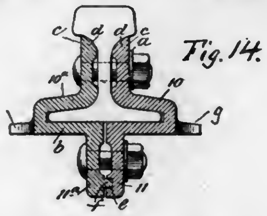


Fig. 13.





wise provided with a cylindrical flange H, entering between the parts A A', where it is riveted.

The smoke-stack top D E consists of the two parts shown, the part D having a flange K fitting between the parts A A', and the part E a flange L for riveting upon the pipe A'. The parts D E fit each other exactly, and are supported in position by the upper and lower riveting, as indicated. By making these parts of continuous pressed steel, as indicated, the weight of the front of the engine is lightened, which is a great advantage at that point, where weight is useless, and the fittings themselves are superior, owing to their great strength, lightness, and cheapness.

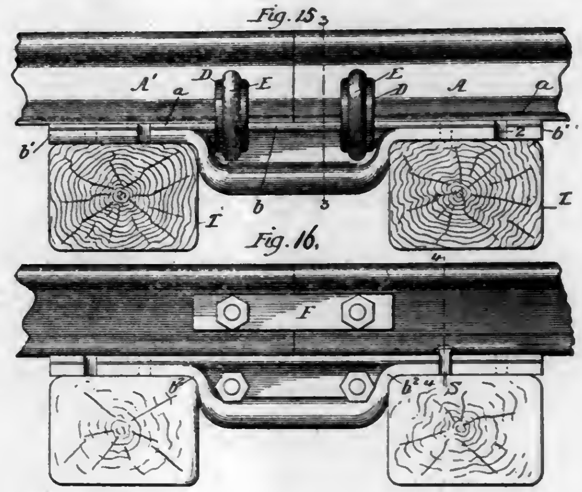
III.—LYND'S RAIL-JOINT.

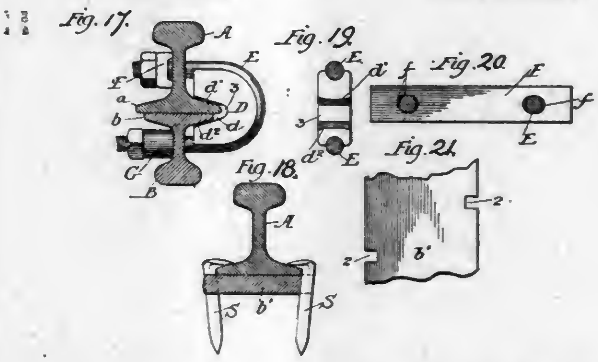
Mr. Ives Lynd, of Troy, N. Y., has patented the rail-joint illustrated by the engravings, which are so clear that they do not require any description. It is shown in figs. 12, 13, and 14—fig. 12 being an elevation, fig. 13 a plan, and fig. 14 a cross-section of the rail and joint.

IV.—MORGAN'S RAIL-JOINT.

Mr. Richard Price Morgan, of Dwight, Ill., has patented the form of rail-joint illustrated in the engravings herewith, which is shown in figs. 15, 16, 17, 18, 19, 20, and 21, and which he describes as follows:

"Beneath the abutting ends of the usual track-rails A and A' extends the sub-rail B, the body of which comprises a top





flange b, corresponding in general contour with the contour of the flanges a of the track-rails above it. The sub-rail B has its ends formed with the flattened or reduced portions b', that rest upon the surface of the cross-ties T, and by preference, also, these flattened or reduced ends of the sub-rails are expanded to a width greater than the width of the flanges of the track-rails, as more particularly seen in fig. 18, in order to permit the expanded ends of the sub-rail to be furnished with suitable slots 2, fig. 21, through which will pass the spikes S, that serve to firmly hold the sub-rail to the cross-ties. By thus flattening the ends of the sub-rail B all necessity for the cutting away of the upper face of the cross-ties is avoided, and a very material saving in expense is thereby secured; and by laterally expanding the ends of the sub-rail to such an extent as to give to these ends a width greater than the width of the superposed track-rails I not only secure broad bearing ends, and thereby save the wear upon the ties, but I am enabled, also, to provide the ends of the sub-rail with slots for the spikes, and thereby secure a much more effective spiking of the sub-rail to the cross-ties than was possible with my prior construction, in which no such expansion of the ends of the sub-rail was made. The body of the sub-rail B is also preferably formed with the somewhat square or abrupt shoulders b^2, fig. 16, which will bear against the sides of the ties T, and will thus serve to better maintain the track in position. Upon the flange b of the sub-rail and upon

the flanges *a* of the track-rails are set the jaw pieces or blocks *D*, that are furnished with suitable seats or indentations *d*, to admit the flanges of both the track-rails and the sub-rail. The seats *d* of the jaws *D* are formed with the bearing-surfaces d' and a^2, adapted to bear, respectively, upon the upper faces of the flanges of the track and sub rails."

Manufactures.

Manufacturing Notes.

THE International & Great Northern Railroad has just placed an order with the Scarritt Furniture Company, St. Louis, for 174 Scarritt-Forney seats of the latest pattern for some very handsome new cars now building. The Chicago & West Michigan Railroad is building six new passenger cars to be furnished with seats of the same pattern. These seats have also been adopted by the Chicago & Alton, the Cleveland, Cincinnati, Chicago & St. Louis, and other prominent roads for their new equipment.

THE firm of Westinghouse, Church, Kerr & Company has recently established its fifth branch office, at No. 511 North Fourth Street, St. Louis, and the southwestern business of the firm will hereafter be conducted from that office.

IT is announced that contracts have been let to the Sprague Electric Railway & Motor Company, New York, to equip all the street-car lines in St. Paul and Minneapolis, Minn., which are owned by one corporation, with electric motors. Before deciding upon any system to be used upon these roads, the President of the Company, Mr. Thomas Lowry, together with the directors, made a careful inspection of all the different methods of operating street cars in large cities, and investigated the merits of each. As a result of this investigation contracts for the partial equipments of the road by cable were cancelled, and negotiations were entered into with the Sprague Company for the entire electrical equipment. By the terms of the contract the Sprague Company is to fully equip and put into working order the entire mileage owned by the Railroad Company, the work to be completed by June 1; the first delivery of electric railroad apparatus, which will include 400 Sprague improved motors for the equipment of the rolling stock, will be made shortly. This is probably the largest order which has ever been given for electric railroad motors, amounting to nearly $2,000,000 in all.

THE Whiting patent cupola, manufactured by the Detroit Foundry Equipment Company, has shown excellent results. One of them in use in the works of the Detroit Car Wheel Company—6 ft. 6 in. outside diameter—during the six months ending January 1 last, melted 13,416 tons of iron without relining. Four of these cupolas are in use in the same foundry and all show nearly as satisfactory results. This seems to establish the claim made for this cupola, that the patent tuyeres used not only accomplish a saving in fuel, but also save the lining of the cupola, making it last much longer than in those of the ordinary pattern. These tuyeres distribute the blast evenly and prevent spotty burning, and in all cases where they have been used have met with approval.

AMONG other orders recently received by the Bucyrus Steel Shovel & Dredge Company, Bucyrus, O., is one for three large steam shovels for the Lake Shore & Michigan Southern Railroad, making seven of these tools furnished to this road. Two of these are the heaviest and strongest ever built, carrying a three-yard dipper and having a capacity of 300 cubic yards in 10 hours.

THE business of the Rollstone Machine Company, of Fitchburg, Mass., has been transferred to a new company recently organized at Anniston, Ala. New buildings are now under construction which will be equipped with tools of the latest pattern, and the transfer will be made about April 1 next.

THE Simonds Rolling Machine Company, Fitchburg, Mass., is making extensive additions to its plant, and is going largely into the manufacture of rolled specialties for railroad work, such as car coupling pins, etc.

AT the Philadelphia Testing-Machine Works of Riehle Brothers, the orders recently received include a United States standard screw-power testing-machine of 35,000 lbs. capacity for the Polytechnic Institute of Alabama, and one of 20,000 lbs. for the Portage Iron Company, Duncansville, Pa.; a transverse testing-machine of 20,000 lbs. capacity for the Tamarack-Osceola Company, Dollar Bay, Mich., and one of 5,000 lbs. for the West Superior Iron Company; a cement tester, 1,000 lbs., for the Missouri Pacific Railroad; track-scales for the Crane Iron Company, Catasauqua, Pa., and for Lees & McVitty, Salem, Va.; charging scales for the Wheeler Furnace Company, West Middlesex, Pa., and the Cranberry Coal & Iron Company, Cranberry, Tenn.; 2,000 lbs. standard test weights for E. P. Allis & Company, Milwaukee, Wis.; Robie screw-jacks (30-ton) for John Lawlor, Prairie du Chien, Wis., the Norfolk & Western Railroad, Roanoke, Va., the Crane Iron Company, Edgehill, Pa., and (10-ton) for H. H. Hobson, Brandon, N. Y.; also for many of smaller scales, twisting machines, power sandsifters and trucks.

THE Dunham Manufacturing Company reports large orders for its Davies lock spike. The Servis tie-plate is also in increased demand, large orders having come in lately. The Company is now making a new pattern, heavier and with an extra flange in the center, for use on roads where the traffic is large and heavy locomotives are employed. Orders for the Dunham car door are also heavy, and a number have been received for Globe ventilators.

Piper's Lamps and Signals.

A VISITOR to Toronto, if he is interested in railroad matters, may be a little surprised to find there a prosperous manufactory of railroad supplies. Nevertheless, he will find that to be the case if he visits the establishment of Messrs. Noah L. Piper & Son, who are engaged in manufacturing a great variety of railroad signal lamps and signals.

They are making a very excellent and substantial

TAIL LAMP,

the cylindrical case or body of which is made of cast-iron galvanized. The socket or leg which supports the lamp is made hollow to admit air for ventilation. The discharge ventilator on top is detachable and can be taken apart to facilitate cleaning. It has deflectors on the sides which direct the current of air, produced by the wind, upward, which thus protects the lamp from being blown out. The lamp also has a central tube in its oil reservoir to prevent the splash of the oil from the motion or concussion of the train, and a small conical ventilator is also attached to the reservoir to allow any gas which may accumulate in it to escape. The air which is admitted at the bottom through the hollow socket is conducted up through openings on each side of the lamp reservoir, and the currents are thus subdivided to greater steadiness to the flame.

The case has generally two Fresnel lenses on opposite sides, although three are sometimes used. All of these are attached to the case by screw frames, and can thus readily be removed.

BUFFER LAMP.

This is similar to the tail lamp, but has four lenses. The same system of ventilation is used with all. The buffer lamp also has a back light to show the engineer whether it is burning.

SWITCH LAMPS.

Several varieties of these are made, all of the substantial character described. One of these is for a three-throw switch. It has two lenses on two of its faces, one large red one and a small white one, the centers of which are located on a diagonal line, so that their position in relation to each other will show which switch is open.

The Messrs. Piper also make hand, steam-gauge, caboose, station, street and ship lamps of various kinds. They also make

SEMAPHORE SIGNALS

with hollow posts. These consist of an internal lining of heavy galvanized sheet iron whose horizontal section is square, the sides being 8 × 8 in. This is cased in planks 2 in. thick on the outside, which makes the post outside 12 × 12 in. It rests on a cedar post at the bottom which is attached to a cross buried in the ground. The cedar post is inserted in the inside of the hollow post. The latter has a pulley on top with a steel chain running over it to raise and lower the lamp. The post has an opening and door at the bottom, through which access may be had to the lamp for trimming and lighting, after which it is hoisted to the top of the post. This makes it unnecessary to go to the top, and facilitates lighting, as there is much better protection from the wind on the inside of the post below than there would be if the lamp is exposed at the top of the post, and the attendant must climb up there to light it.

The colored lenses are attached to a rectangular case on the inside of the post and outside of the lamp. This case is operated by a rod which connects it with, and is moved by, the semaphore, the position of which determines that of the lenses.

Mr. Piper is also the inventor of a system of interlocking signals for railroad crossings and drawbridges, which is very ingenious. He has applied the same system of signals to gates for street crossings, and he has models of all of them on exhibition in his warehouse, which at present is opposite the Rossin House.

Bridges.

THE following bridge companies are actively at work putting in plants for the manufacture of steel eyebars; Pencoyd Bridge & Construction Company; Phœnix Iron Company; Passaic Rolling Mills; Smith Bridge Company; King Iron Bridge & Manufacturing Company; Elmira Bridge Company. It is probable that of the several processes of upsetting the grooved die, the nest of rollers and the rocking half-roller will each have a trial. It is rumored that there is a patent now being perfected by which upsetting and forging may both be accomplished at once under the steam hammer.

THE Edge Moor Bridge Works have secured extensive contracts from the Norfolk & Western Railroad, including the heavy steel bridge across the Ohio at Ceredo, and a large coal dock at Norfolk, besides much small bridge work.

THE Kansas City, Fort Scott & Memphis Railroad has let the contract for five plate-girder spans to the Pencoyd Bridge & Construction Company.

THE shop work on the Memphis Bridge will shortly be commenced at the Athens shop of the Union Bridge Company. The bridge will be entirely of steel and will comprise a continuous superstructure 2,258 ft. 4 in. long, built on the cantilever principle, and a deck span 338 ft. 9 in. long. The continuous superstructure will be composed of a central span 621 ft. 0½ in. long, from each end of which projects a cantilever arm 169 ft. 4½ in. long; of an anchorage span 225 ft. 10 in. long, from which will project a cantilever arm like those above mentioned and two intermediate spans each 451 ft. 10 in. long. The continuous superstructure is, therefore, divided into one span of 225 ft. 10 in., one of 790 ft. 5 in. and two of 621 ft. 0½ in. The 790-ft. span will be the longest cantilever span in this country, and will exceed the Red Rock Bridge, now under construction, by 130 ft. The estimated weight is 13 000,000 lbs. for the continuous superstructure, and 1,000,000 lbs. for the deck span.

THE contract for the extension of the Hudson County Elevated Railroad of Jersey City from the present terminus to the Court House, was let to the Passaic Rolling Mill Company, Paterson, N. J. The work is now in the shops and being turned out rapidly.

OBITUARY.

HENRY WOODS, who died in Ottawa, Canada, March 8, aged 67 years, was for 20 years in charge of the construction of bridges on the Grand Trunk Railway. For a number of years past he had been Bridge Inspector on the Canadian Pacific.

ASSISTANT NAVAL CONSTRUCTOR CHARLES H. HEWES, U.S.N., died of typhoid fever in Norfolk, Va., March 18. He graduated from the Naval Academy in 1883, at the head of his class, and was regarded as one of the best of the younger officers in his department of the service.

LEONARD EVERETT, a well-known and wealthy engineer and dredging contractor, died at Lockport, N. Y., March 18, aged 70 years. He was born at Canton, Mass. At the time of his death he was General Superintendent of the American District Steam Company, which has plants all over the country.

EBENEZER L. ROBERTS, who died in Brooklyn, N. Y., March 13, aged 65 years, was born in Middletown, Conn., and trained as a practical builder. In 1850 he removed to New York and became a very successful architect and builder. He had charge of the construction of a number of large buildings, including those of the Standard Oil Company and the Ninth National Bank on Broadway, several churches, and many private residences. He also built the Amherst College gymnasium and other buildings in various parts of the country.

PERSONALS.

ARTHUR POU has been appointed Chief Engineer of the new Florida, Midland & Georgia Railroad.

MAJOR H. WADSWORTH CLARKE has been appointed City Engineer of Syracuse, N.Y. He is an engineer of wide experience.

L. M. BERRIEN has been appointed Principal Assistant to the Chief Engineer of the New York, New Haven & Hartford Railroad.

LOCKWOOD, GREENE & COMPANY, Engineers and Mill Architects, have removed their office to the Rialto Building, 131 Devonshire Street, Boston.

JOHN WILEY & SONS, the well-known publishers of engineering and scientific books, have removed their offices from No. 15 Astor Place to No. 53 East Tenth Street, New York City.

HON. WARNER MILLER, of New York, has been chosen President of the Nicaragua Canal Construction Company, succeeding A. C. CHENEY, who remains with the Company as Vice-President.

E. A. CANNON, for the past two years Assistant U. S. Engineer in charge of the Elk River Division of the Muscle Shoals improvement in the Tennessee River, has resigned, and will return to Minneapolis, Minn.

JOSEPH W. SILLIMAN, C.E., has been appointed Professor of Engineering in Allegheny College, Allegheny, Pa., to succeed W. S. TWINING, who has resigned in order to accept a position with the Thomson-Houston Electric Company of Boston.

ARTHUR CRANDALL has been appointed Secretary of the Dunham Manufacturing Company, with office in the Phœnix Building, Chicago. He has for some time represented the Company in Chicago and the Northwest.

M. F. BONZANO has been appointed Assistant General Superintendent of the Philadelphia & Reading Railroad. He has been on the road 10 years, serving as Supervisor, Division Engineer and Division Superintendent.

CHARLES BLACKWELL has resigned the office of Assistant Superintendent of the Toledo, St. Louis & Kansas City Railroad, and has accepted a position with the manufacturing firm of Shoenberger & Company, of Pittsburgh.

C. H. WALTON has been appointed Superintendent of the Cincinnati & Muskingum Valley Railroad, in place of F. G. DARLINGTON, who is appointed Division Superintendent of the Chicago, St. Louis & Pittsburgh Railroad.

CAPTAIN N. H. FARQUHAR, U.S.N., has been appointed Chief of the Bureau of Yards and Docks in the Navy Department, with the relative rank of Commodore. Captain Farquhar was in command of the *Trenton* when that vessel was lost at Samoa.

JAMES MCCREA has been chosen Second Vice-President of the Pennsylvania Company, to succeed the late William Thaw. Mr. McCrea's successor as General Manager of the Company's lines is JOSEPH WOOD, heretofore General Superintendent of Transportation.

FRANK S. GANNON has been appointed Eastern General Superintendent of the Baltimore & Ohio, and will have general charge of all that company's interests east of Philadelphia. He will continue to act as General Superintendent of the Staten Island Rapid Transit lines.

ROBERT I. SLOAN, late Chief Engineer of the Manhattan Elevated Railroad in New York, has been appointed Chief Engineer of the new Southside Elevated Railroad in Chicago. His successor as Chief Engineer of the Manhattan Elevated is JOHN WATERHOUSE, heretofore Principal Assistant Engineer.

CHARLES WATTS has been appointed General Superintendent of the Pennsylvania Company's lines, including the Pittsburgh, Fort Wayne & Chicago and allied lines. Mr. Watts has had nearly 25 years' experience, serving as conductor, station-master and as Trainmaster of the New York Division of the Pennsyl-

vania Railroad, and for some time past as Division Superintendent of the Chicago, St. Louis & Pittsburgh Railroad.

PROCEEDINGS OF SOCIETIES.

American Institute of Mining Engineers.—The spring meeting of the Institute began in Washington, February 18, the sessions being held in the National Museum. The usual addresses of welcome were made and responded to, and memorials of Dr. Ashburner and Franklin B. Gowen were read.

On the second day the members took an excursion to Mount Vernon in the morning. In the afternoon a business session was held, at which papers were read by H. Mendenhall on Standard Weights and Measures; by John Birkinbine on Magnetite in the Mines at Port Henry; and by F. A. Pocock on Electricity in Mines, the last-named paper describing the electric haulage at the Hillside Mine in Scranton. Papers were also read by Richard Pearce and F. H. McDowell.

On the third day, in the morning the members visited the Navy Yard, in the afternoon attended a reception at the White House, and in the evening the annual banquet of the Institute, which was held at the Arlington Hotel.

On the fourth day two sessions were held, which were chiefly given up to reading and discussing papers upon Aluminum. These papers were by Messrs. A. E. Hunt, G. H. Abbott, E. H. Cowles, W. H. Keep and F. P. Dewey. In these papers and in the discussion many interesting facts were stated in regard to the present condition of the manufacture of aluminum, and its use in alloys with other metals.

At the closing session the annual reports were presented, showing the Society to be in good condition financially, with a total of 1,968 members. Professor S. Munroe read a paper on Modern Methods in Surveying.

This closed the business of the meeting, but on the next day, February 22, a number of the members visited by invitation the gold mines now being developed in Montgomery County, Md., 15 miles from Washington.

Association of Manufacturers of Chilled Car-Wheels.—The regular meeting was held in New York, November 21, Mr. W. W. Snow in the chair. Mr. Whitney presented a report regarding the action of the Master Mechanics' and Master Car-Builders' Association with reference to the Conference Committee report. This enclosed the form of specifications for cast-iron wheels which was adopted by the Master Mechanics' Association in 1888, and by the Master Car-Builders' Association—with some slight modifications—in 1889. These specifications have been already noticed. The Report of the Committee concluded with the following resolutions and was accepted by the meeting:

"*Resolved*, That this Association accepts, with satisfaction, the action of the American Railway Master Mechanics' and of the Master Car-Builders' Associations, upon the report of the Joint Conference Committee on Specifications and Guarantee for Chilled Cast-iron Wheels, with the understanding expressed in the following preamble and resolutions:

"'*Whereas*, the wheel-maker has no control of the conditions of railroad service,

"'*And whereas*, such conditions vary materially on different roads, Therefore, *Resolved*—

"'1. That in all mileage or time guarantees, the wheel-maker ought to be held responsible only for wheels which fail through faults of material or workmanship.

"'2. That when wheels are taken out of service on account of sharp flanges, flat spots, comby or shelled-out treads, or for cracked brackets or plates, and it is found on breaking up the wheels that the depth and character of the chill and the strength and character of the metal in the plates are up to the standard specifications adopted by the Joint Conference Committee of the American Railway Master Mechanics', the Master Car-Builders', and the Wheel-Makers' Associations, it shall be considered that the failure is due to the service, and not to the quality of the wheel, and that the wheel-maker ought not to be called upon in such cases to pay for or replace any such wheels.'"

The following officers were elected: President, Frank J. Hecker; Vice-President, W. W. Snow; Secretary, William W. Lobdell; Treasurer, N. P. Bowler; Members of the Executive Committee, John R. Whitney, N. S. Bouton, W. S. G. Baker, C. H. Zehnder, and T. A. Griffin.

At the evening session a committee was appointed to confer with the Master Mechanics' and the Master Car-Builders' Association with reference to the subject first expressed in Mr. Whitney's report and resolution. The President appointed the Executive Committee for this purpose.

Resolutions were presented and passed, expressing respect for the late William H. Barnum. Notice was given that a motion would be made to amend Article III. of the Constitution. It was resolved that the next annual meeting be held in New York on the fourth Wednesday in October, 1890.

International Association of Car Accountants.—The Committee on Discussion has issued a circular suggesting the preparation of papers to be read at the annual convention, and asking members to prepare such papers. The Committee suggests the following as good subjects for papers:

1. Straight Per Diem; its advantages over mixed.
2. Mixed Per Diem; its advantages over straight.
3. The cause of the constantly decreasing mileage of freight cars on home lines; what are the remedies?
4. The Car Record Office. Presentation of some form of blank by members, with explanation of its presumed superiority over others—for example: Record Books, Foreign Record, Conductors' Bills, etc. (Not more than one or two kinds of blanks will be considered.) Work in Car Record Office, Unnecessary Work, Piece Work, Passenger Car Records and Mileage.
5. Traveling Car Agents; how their work should be done to be most effective.
6. Car Distribution; how best attained; limitations.
7. The Demurrage Bureaus. What has the experience of a year shown as to their efficiency?
8. Detention of foreign cars on roads, and what should be done to prevent it.
9. Diversion of cars and the advisability of adopting pecuniary penalties to remedy it.

Answers should be sent to the Chairman of the Committee, Edmund Yardley, at Pittsburgh, not later than April 15, when the Committee will make a selection and assign a time for reading each paper to the Convention.

National Electric Light Association.—The annual meeting of this Association was held in Kansas City, Mo., February 11, 12, 13 and 14. Besides the general routine business, a number of interesting papers were read, including, among others, one on the Economic Generation of Steam, by George H. Babcock; on Safety Devices in Electrical Installations, by Professor Elihu Thompson; on Electric Railroads, by F. J. Sprague. All these papers and others were discussed. Reports were received from the Committees on the Duty on Copper; on Underground Conduits; and on Standard Potentials for Street Railroads.

The following officers were elected for the ensuing year: President, M. J. Perry, Providence, R. I.; First Vice-President, E. A. Maher, Albany, N. Y.; Second Vice-President, C. L. Edgar, Boston; Executive Committee, C. R. Huntly, Buffalo, N. Y., Chairman; E. R. Weeks, Kansas City; James E. English, New Haven, Conn.; J. J. Burleigh, Camden, N. J.; M. D. Law, Philadelphia; M. J. Francisco, Rutland, Vt.; A. F. Mason, Boston; J. A. Seely, H. K. Thurber, New York.

The standing committees for the ensuing year are on Revision of the By-Laws and Constitution; on Underground Conduits and Conductors; and on Relations between Parent and Sub-Companies.

American Society of Civil Engineers.—At the regular meeting, March 5, Dr. Charles E. Emery described the construction of the plant of the New York Steam Company, stating the difficulties encountered and the methods adopted to overcome the same. His paper was illustrated by stereopticon views. The discussion was postponed to the next meeting.

It was announced that the amendment which consisted of a codification of the present text of the Constitution had been adopted; also the amendment to Article IX. It was also announced that the memorial to Congress reported by the Committee on Union Standard Time in favor of 24-hour notation had been adopted. The tellers announced the following elections:

Members: Henry W. Ayres, New Britain, Conn.; George H. Clark, Cedartown, Ga.; Potter D. Ford, Long Island City, N. Y.; Thomas J. McMinn, New York.

Juniors: Kennerly Bryan, Charles F. Parker, New York; Philo S. Perkins, Elmer W. Ross, Irving S. Wood, Providence, R. I.; Clark W. Thompson, Duluth, Minn.; Ernest J. Purslow, Santa Barbara, Cal.; Owen L. Ingalls, Washington.

At the regular meeting, March 17, Dr. Charles E. Emery continued his description of the details of construction of the plant of the New York Steam Company, which was begun at a previous meeting, stating in general the difficulties encountered and the methods adopted to overcome the same, and discussing the measure of success attained with district steam systems in New York and elsewhere, and the probable future of enter-

prises of this kind. The subject was illustrated by stereopticon views, and a discussion by the members present followed.

American Society of Mechanical Engineers.—The twenty-first Convention of this Society will be held in Cincinnati, O., beginning on the evening of Tuesday, May 13. Papers for this meeting are already in the Secretary's hands, and queries for the Topical Discussions should be sent in at once.

The meeting occurs the week before the great musical festival in the same city, making it possible for members who desire it to attend both reunions.

New England Railroad Club.—At the annual meeting in Boston, March 12, the following officers were elected: President, George Richards; Vice-President, Orlando Stewart; Secretary and Treasurer, Francis M. Curtis; Executive Committee, George Richards, F. D. Adams, J. N. Lauder, Albert Griggs, J. W. Marden, F. M. Twombly, and John Coghlan; Finance Committee, George Richards, Charles Richardson, Isaac N. Keith, Daniel S. Page, A. G. Barber, Osgood Bradley, Joel Hills, and George H. Wightman.

The subject for discussion being Freight-Car Couplers, the Secretary read the circular sent out by the Executive Committee to the trainmen of the New England railroads, asking them to signify their preferences for the various styles of couplers. The result of the investigation was given simply by announcing that the total number of signers was 1,948. Of this number 1,239 preferred the Safford, 557 the Janney, 63 the old style link-and-pin, 30 the Boston automatic, 26 the Gould, 25 the Miller hook, 5 the Marks, 2 the Dowling, and 1 the Cornell. The Committee deemed it best to combine the replies into two types, and by doing that 1,282 approved the Safford link-and-pin type, and 641 favored the Janney vertical-plane type.

The discussion was carried on by Messrs. Adams, Marden, Shinn, Coghlan, Lauder and others, who gave some accounts of experience on their respective roads with different types of couplers.

New England Water-Works Association.—The quarterly meeting was held in Boston, March 12. In the morning the members visited the works of the Hersey Meter Company in South Boston.

At the meeting several papers were read. One, by Mr. Horace Holden, on Water Rates, called out a long discussion, in which many members took part.

Boston Society of Civil Engineers.—At the regular meeting, February 19, Frederick W. Farnham, Willard M. Foster, Alfred E. Nichols and T. S. Pearson were chosen members. The President announced the death of Lincoln Cabot, a member, at Honolulu in December last. William E. McClintock was elected Vice-President, and Professor W. S. Chaplin a director for the ensuing year.

Captain Eugene Griffin, General Manager of the Railroad Department of the Thomson-Houston Electric Company, read a paper on the Transmission of Power by Electricity. This paper was discussed by Messrs. Blodgett, Pearson, Tilden and others.

Engineers' Club of Philadelphia.—At the regular meeting, March 1, the Secretary presented, for Mr. Howard Constable, an illustrated paper on the Re-enforcement or Underpinning of the Iron Piles of a Draw-bridge Pier.

Mr. Barton H. Coffey presented a paper on Sand Filtration. This was discussed, Mr. Howard Murphy expressing the opinion that some day it would be necessary to adopt a separate system of water supply to furnish the comparatively small quantity required for strictly personal and domestic uses from pure sources, while other sources not capable of yielding potable water could be drawn upon for the large quantities required for manufacturing and general uses.

Mr. Henry G. Morris described a new method of Sinking Dies, showing a specimen of the results, which, he said, could be obtained by this process at a much lower cost than by the old method.

Engineers' Club of Kansas City.—At the regular meeting, February 3, a committee was appointed to arrange for the annual dinner on February 28.

Mr. Thomas Knight read a paper on Geological Field Work in Southern Missouri, the object of the work being to ascertain the mineral resources of the country and the best plans for their development.

Engineers' Society of Western Pennsylvania.—At the regular meeting, January 21, John M. Goodwin, H. S. Morris, F. S. Smith, L. B. Stillwell and William Whigham were elected members. The Treasurer presented a report showing expenditures of $1,447 for the year, and a balance of $280 on hand. The Secretary reported that there were now 336 members, and that 10 meetings had been held during the year.

It was resolved to adopt the report of the Committee on Union of the Various Societies, and also resolved that the Society is ready to join with others in occupying a common home under suitable conditions when offered by the Pittsburgh Academy of Science and Art.

The following officers were elected for the ensuing year: President, W. L. Scaife; Vice-Presidents, Phineas Barnes and A. E. Hunt; Directors, R. N. Clarke, W. G. Wilkins, William Metcalf, and M. J. Becker; Secretary, S. M. Wickersham; Treasurer, A. E. Frost.

Mr. J. A. Brashear read a paper on the Refinements of Modern Measurements and Manipulation, describing a number of the devices invented for making fine and close measurements.

Civil Engineers' Club of Cleveland.—At the regular meeting in Cleveland, O., February 11, Arndt Angstrom and James Wallace were chosen members.

Mr. Edward Lindsley read a paper on Improvement in Railroad Terminal Facilities, in which he reviewed the appliances for transferring heavy freights and unloading vessels.

Mr. James Ritchie read a paper on Specifications for Steel and Iron, in which he advocated the adoption of standard specifications for steel, with certain requirements for tensile strength, elongation, etc. This was discussed, bringing out some interesting statements about the relative advantages of steel and iron.

Mr. W. H. Kingsley read some notes on the Water Works Lake Tunnel, speaking of the difficulties encountered in building the tunnel under the lake at Cleveland.

President Holloway made some remarks about the American Society of Mechanical Engineers, and its new quarters in New York.

Western Railway Club.—At the regular meeting in Chicago, March 18, the first subject for discussion was the Interchange Rules, the object being to suggest changes which may seem expedient to present to the Master Car-Builders' Convention in June.

The second subject was Counter-balancing Locomotives, which called out a very lively discussion, many members taking part.

Engineering Association of the Southwest.—At the regular meeting, February 13, Berien L. Blackie was chosen a member; Alfred Hume, J. Price Jackson, and Tyler Calhoun, Juniors. In view of the number of non-resident members, it was resolved to hold one meeting in three at some point outside of Nashville, and to postpone for the present the furnishing of permanent quarters in that city. A number of photographs of bridges was received. A resolution for the appointment of a special committee on Highway Reform was referred to letter-ballot.

Mr. Linn White read a paper on a Passenger Incline Railroad on Cameron Hill, Chattanooga, Tenn., describing the road which was built by Messrs. Guild & White for the Chattanooga Water & Power Company, and was opened for traffic in October last. This paper was discussed by members present.

At the regular monthly meeting which was held in Nashville, March 13, Charles O. Bradford, James A. Fairleigh, Joseph W. Walker and Bernard A. Wood were chosen members; William M. Leftwich, Jr., a junior. The appointment of a special committee of five members on Highway Reform was ordered. A communication was received from the *Tradesman* of Chattanooga, offering a cash prize of $25 for the best paper read before the Association by any member between December, 1889, and April, 1890, the award to be made by the Executive Committee. The proposition was accepted.

Mr. C. A. Locke read a paper on the Government Survey of the Cumberland River below Nashville in 1889, which contained an account of the regimen of the river, the results of the examination for suitable sites for locks and dams and an exhibit of the results of the improvement on navigation. A discussion followed, in which Mr. Joseph W. Walker submitted drawings and descriptions of a form of movable dam in consideration for this river. Dr. W. L. Dudley submitted an analysis of a peculiar mineral found in borings near the mouth of the river, and

Professor F. W. Clarke pronounced the mineral a very peculiar one.

A Paper by Mr. George Reyer on Tests of the Pumping-Engines of the Nashville Water Works was read by title only, and will be published.

The April meeting will be held in Louisville, and will be devoted to the subject of heavy submerged bridge foundations.

Northwest Railroad Club.—At the monthly meeting in St. Paul, March 8, the subject for discussion was Journal Brasses. It was opened by Mr. G. S. Warren, who read a paper giving the results of some tests and experiments made with different brasses on both Iron and steel journals. The discussion was continued by Messrs. Sceets, Whitaker, Pattee, Fraser, Barber, Ward and others, many different opinions being expressed both as to the best form of brasses and the metal to be used. The discussion was not finished, the subject being continued to the April meeting.

Engineers' Club of St. Louis.—At the regular meeting, March 5, William A. Neff, Jr., and Julius Pitzman were elected members.

Mr. Willard Beahan read a paper on American and Foreign Railroads, giving the results of observations in Panama, South America, France, England, Scotland and Ireland. Some description was given of the topography of the countries traversed, from the point of view of a railway locating engineer. The road-beds of the railroads were described, together with their ties, rails, ballast grades, curves and bridges. Some information was also given as to the locomotives used, and the rolling stock, speed, and the class and nationality of men employed to operate the roads. Comparisons were made between American and foreign railroads on the points of original cost, maintenance and operation, showing wherein American roads excelled and wherein they might learn something. The iron ties used in South America were described. A brief description was also given of the Forth Bridge. The discussion was participated in by Messrs. Robert Moore, J. B. Johnson, Meier, Ferguson, Curtis, Crosby, Long and Gayler.

Mr. Moore stated that lignum-vitæ ties were being used successfully in Mexico. Their cost was about $1 each, and they lasted indefinitely.

At the regular meeting, February 19, William E. Barnes, Emerson McMillin, and John H. Pope were elected members.

A paper by Mr. Edward H. Connor on the Substructure of the Cairo Bridge was read. It was accompanied by drawings, showing the piers and caissons, and explaining the work of construction in detail. This paper was generally discussed by members present.

Mr. Willard Beahan gave some information regarding the outlook for engineers in South America. He stated that railroads were few, but a number were projected, and that municipal engineering was just being taken up. Most of the engineers now in that country are French.

Montana Society of Civil Engineers.—At the regular meeting in Helena, February 15, O. C. Dallas, Frank C. Jones, James L. Buskett and Finlay McRae were chosen members.

It was ordered that the following standard Committees be appointed for the current year: On Public Works; on Affiliation with the American Society of Civil Engineers; on Public Land Surveys; on Library and on Topics.

The Committee appointed on the Revision of the United States Mining Laws made an interesting report of progress, and was continued to make a final report at the next meeting.

Tacoma Society of Civil Engineers and Architects.—At the regular meeting in Tacoma, Wash., February 20, H. C. Ward was elected a member.

The new President, Mr. D. W. Clarke, made a few well-chosen remarks as an opening address for the year.

Mr. C. E. Grafton read a paper on the Bituminous Coal-Fields of Pennsylvania. In the discussion which followed some points were brought out in relation to the coal-fields of Washington. As to extent and quality they seem to compare well with those of Pennsylvania, but mining is somewhat more difficult, as the dip of the measures is 30° to 40°, against 15° to 20° in Pennsylvania. In Washington there are no good indications of oil or natural gas, but limestone, marble and building stone are abundant. The precious metals are also successfully mined in some parts of the State. Its resources are now being rapidly explored and developed.

NOTES AND NEWS.

New York State Canals.—The annual report of Mr. John Bogart, State Engineer of New York, for the year ending September 30, 1889, is chiefly devoted to the improvements made in the canal locks. Since 1886 the length of the locks has been doubled in 27 cases on the Erie Canal, and seven others are now under construction, and will be finished by the opening of navigation this spring. Seven locks on the Oswego Canal have been lengthened, and two others are under construction. The new locks are 220 ft. in length, between gate-posts. This makes a great saving of time, as two boats can be passed through the new locks at once, and there is no delay where boats are run in pairs, which is now a common practice on a canal.

The report says that the machinery for drawing ascending boats into the locks has been improved by the substitution of iron frames in place of old timber frames. These are neat and strong, and save much time both in hauling in boats and starting them out. Wire cables were tried with machinery, but have not proved satisfactory, as they are heavy to overhaul, and wear rapidly, so that they break easily. Experiments were made with regard to the advantage of opening one or more of the paddle-valves in the gates and thus drawing a boat into the lock and flushing it out more quickly than could otherwise be accomplished. It was found that in drawing in boats only one paddle could be used advantageously, because with more than one the boat is likely to damage the gates and coping. In swelling out the gain in time with three paddles was found to be very slight over two paddles, so that it is now considered advantageous to use one paddle in drawing in and two in swelling out. By this means there is shown a gain in time of about 20 minutes per lock. The introduction of the turbine wheel to run machinery for hauling ascending boats into the locks is a great advantage. Indeed, without such machinery it would be difficult to get a double-header into a lock.

The average evaporation in the canals during the dry season is estimated at 33½ in. daily. The loss from leakage and filtration is estimated at 229.3 cubic feet per mile. The use of double-headers necessitates the widening of the towpaths, and 18 ft. has been decided upon as the standard width of a towpath, that being the least width in which two triple teams can pass.

With regard to the improvement of the Hudson River between Troy and Coxsackie, the report declares that unless the United States Congress directs vigorous action immediately to this work the State of New York will have to exert itself to insure free navigation in that part of the Hudson River. Dredging has been carried on in the Albany Basin during the year, but the sewage of Albany is again filling up the basin. The State Engineer recommends the radical remedy of a sewer emptying below the basin.

The report urges the continuation of improvements on the Champlain Canal until the whole canal is of the enlarged size of 6 ft. depth, 56 ft. width on water surface, and 44 ft. width on bottom. The importance of the Champlain Canal is shown by the tonnage of 1,168,304 tons carried in 1888, which is fast increasing.

The Black River Canal is referred to as of great value to the northern ports of the State, where a large lumber business is transacted. This would not be possible without water transportation. During the year improvements were made on the Cayuga and Seneca and Chemung canals, and a survey was made of the Genesee Valley. The result of the latter is the conclusion that a storage-reservoir of remarkably large capacity can be constructed.

The total engineering expenses for the fiscal year were $86,-280. The organization of the department is reported to be substantially the same as in previous years. The engineering and clerical staff now consists of 3 division engineers, 3 resident engineers, 9 assistant engineers, 13 levelers, 15 sodmen, 20 chainmen, 1 chief clerk, 1 engineer in charge of the work of the department connected with the lands of the State, 1 canal clerk, 1 stenographer, and 1 clerk.

A Chief Engineer's Duties.—The following circular, issued by the Union Pacific Company on January 1, defines the duties of the Chief Engineer of that road: "From this date he will have on the entire system:

"1. Charge of surveys and reconnoissances of all proposed new lines, and reports thereon.

"2. Charge of construction of new lines, and of all structures and work pertaining thereto, including, except in special cases, the procurement of right of way.

"3. Charge of the inspection of truss bridges and tunnels, and supervision of important repairs or renewals connected

therewith, and the inspection of all structural iron in its manufacture.

"4. The preparation of plans and specifications for, and construction of, all important special structures, such as shops, division terminals and depot buildings, for which special plans are required, and the preparation of all important yard plans.

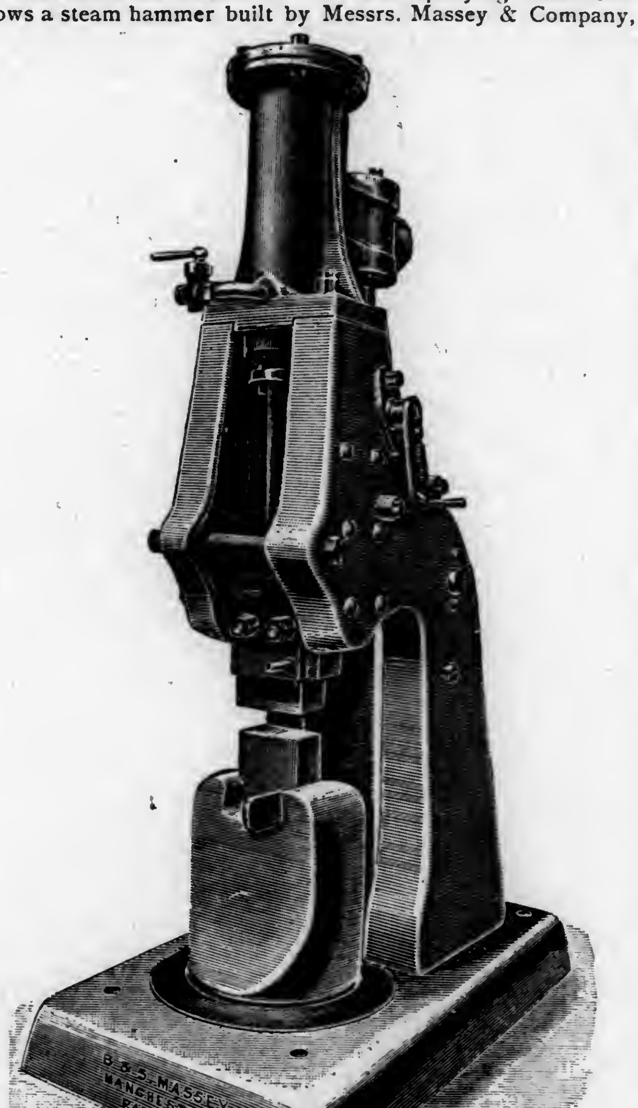
"5. The preparation and approval of standard plans for the maintenance and renewal of roadway, track, and roadway materials, buildings, bridges, and all other structures.

"6. The preparation and charge of right-of-way and lease records; preparation and charge of mileage and distance records, of all main tracks, sidings, spurs, etc., of every description. Also records of track composition, ballast, and tie charts.

"7. The preparation and care of records of bridges, buildings, and all other structures.

"8. And such other work as may be assigned by the Vice-President, to whom he will report direct."

A Steel-Frame Hammer.—The accompanying illustration shows a steam hammer built by Messrs. Massey & Company,



of Manchester, England. It is an ordinary small double-acting hammer, the peculiarity being that the frame used is of steel instead of the ordinary cast-iron frame. The standards and base-plate are made of Siemens-Martin steel, flanged by a steam forging press. There is no welding whatever, and the opening for the anvil-block is punched through the base-plate. The two standards are held together by bolts, as shown in the illustration, and the guides for the hammer-head are riveted on as indicated. This form of frame is covered by a patent issued to Messrs. Massey.

A New Ocean Steamer.—The Compagnie Générale Transatlantique will this year have a representative in the latest class of the ocean steamers, in the steamer *La Touraine*. The construction of this vessel is now going on at the yards of the company at Penhoet, near St. Nazaire, France, where their previous ships have also been built. The plans for *La Touraine* indicate that her speed will be much greater than that of any of her predecessors. She will be 8,000 tons burden, or 1,000 tons larger than the *Bourgogne*, *Bretagne*, *Gascogne*, and *Champagne*, while her H.P. will be increased from 8,000, as in the older boats, to 12,000 She will be provided with twin screws, and with a triple-expansion engine of the type which was first introduced on Atlantic lines by the French line. The general appearance of *La Touraine* will be much the same as that of the last two steamships built at Nazaire—the *Champagne* and the *Bretagne*. The metallic portions of the hull are of the highest grade of steel from the foundries of Terre Noire, and the woodwork is of teak and Canadian elm. The decorative work will be the best that French art can contrive, and the famous *cabines de luxe* of the older vessels will, if possible, be surpassed. Like all French mail steamers, the *Touraine* is built under contract with the Government, and will be fitted for the carrying of heavy guns. It is expected that *La Touraine* will be completed in time to make her maiden trip in April next. There is also in course of building at Penhoet a new steamship for the Transatlantique's Mexican line, running from St. Nazaire to Vera Cruz. This vessel is to be named *La Navarre*. She will be of 6,300 tons, and will develop 7,000 H.P. Her speed will be such as to admit of her being placed on the New York line, if necessary. Two other passenger steamers for the Algiers line, the *Maréchal Bougaud* and the *Ville d'Alger*, are also being built. They will be like the present *Eugene Perière*, and of 2,000 tons and 3,000 H.P.—*The Steamship.*

The St. Clair Tunnel.—The construction by the Grand Trunk Railway Company, of the tunnel under the St. Clair River, between Port Sarnia, Ont., and Port Huron, Mich., has slowly progressed during the past two years. The undertaking has proved to be difficult and expensive, involving an immense outlay of money in preliminary and experimental work. The length of the tunnel will be 6,000 ft., of which 3,310 ft. will be under the river, 2,160 ft. under dry land on the Canadian side, and 2,330 ft. under dry land in Michigan. Of the portion under the river, 1,500 ft. will be nearly level. At either end of this part of the tunnel, there will be a great rising, at the rate of 105.6 ft. per mile, which will continue through the open cuttings from the approaches. The total length of the ascent at the Canadian end will be 4,970 ft., and at the American end, 4,900 ft. The length of the open cutting at the east end of the tunnel will be 3,270 ft., and at the west end, 2,300 ft. The depth of the lowest part of the tunnel below the surface of the water will be 88½ ft. The minimum depth of the top of the tunnel below the bed of the river will be 15 ft. The tunnel will be for single track only. In cross-section it will be circular, with a clear internal diameter of 20 ft. The lining will consist of cast iron, of which about 6,000 tons have been manufactured and delivered upon the ground ready for use. The construction of the tunnel is being carried on by the company without contractors.

The plant consists of winding engines, ventilating machinery for exhausting foul air, with a capacity of 600,000 cu. ft. per hour; steam-pumps, with capacity of 5,000 gals. per minute; electric light plant; shields weighing 60 tons each for the protection of the men at work, hydraulic machinery for propelling the shields, with a power of 3,000 tons each. As the work is progressing from both sides of the river all work is in duplicate.

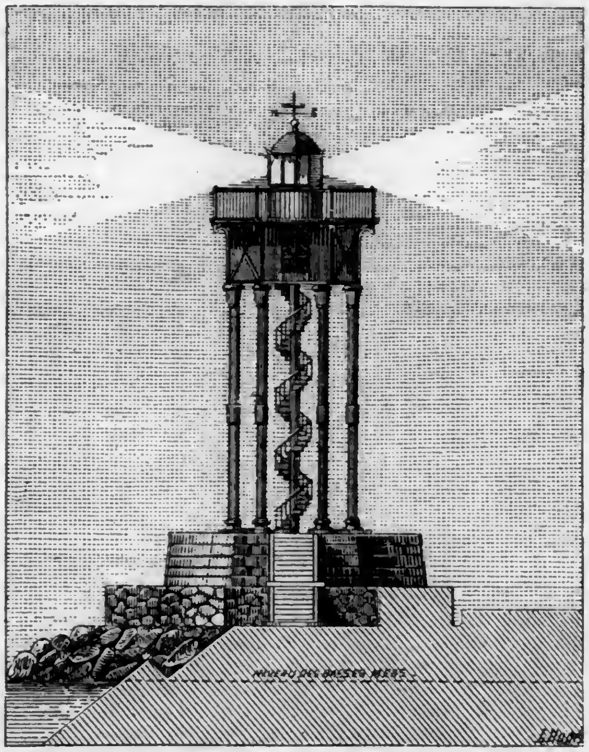
The advantages to be gained by the construction of the tunnel are a reduction of the expense and time of transporting trains, and a degree of regularity in the service not attainable by ferry, in consequence of the river being obstructed by ice in winter and by vessels during the season of navigation. The tunnel is being built at this particular point for the following reasons: The comparatively shallow depth of water at the proposed crossing; the tunnel and its approaches can be constructed on the same straight line; the short length of new railroad that will be required for all practical purposes; the tunnel approaches connect immediately with the main lines of both the Grand Trunk and the Chicago & Grand Trunk railroads; the favorable material in the bed of the river, the borings showing that the rock is from 90 to 95 ft. below the surface of the river, and that it is overlaid with clay.

The tonnage passing up and down the river is estimated to be nearly five times as much as that passing through the Suez Canal. The necessity of a tunnel is shown by the immense amount of traffic that is annually carried on across the St. Clair River in connection with the Grand Trunk Railway. During the year ended June 30 last, 184,000 through cars and 13,500 local cars were transferred by ferries here, making a total of 197.500 cars that passed over that year. This is an average of over 541 cars per day, including Sundays, or about 2.26 cars per hour, which is equivalent to the crossing of a boat-load of cars every 48 minutes.

The total cost of the tunnel is estimated at $2,500,000, of which the company has been granted a subsidy of $375,000 by the Dominion Government. The present pay-roll averages about $9,000 per month.

It is expected that this great work will be completed by the last of the year 1890.—*Report of Consul J. S. Farrar to the State Department.*

A French Lighthouse.—The accompanying illustration, from *Le Genie Civil*, shows a lighthouse recently erected at the



extremity of the breakwater at Port Vendres. It stands in a very exposed position, where high waves frequently break over it, and the intention was to combine strength of construction with the least possible resistance to the force of the waves.

The lighthouse is supported on six metallic columns arranged in the form of a hexagon. These columns are 14.50 m. (47.56 ft.) in height and are 2.20 m. (7.41 ft.) apart. Each column is formed of three parts; the lower is 0.30 m. (11.8 in.) exterior diameter, and is sunk 2 m. (6.56 ft.) in the solid masonry which forms the base of the tower. The middle section has the same diameter, but somewhat less thickness, and is joined with the lower one by means of a threaded sleeve. The upper part is joined to the middle section in the same way, and is united at its upper end with the metal framework which forms the floor of the light-chamber or lantern. The beams supporting the light-keeper's room are carried on brackets attached to the upper end of the second section of the column. The floor of this chamber unites the columns, the space below being left entirely clear, except as noted, in order to oppose least resistance to winds and waves.

The supporting columns were made especially for this work. They are of rolled iron welded on a mandril. This construction required some special arrangements which increased the price of the work, but was adopted because it presented the greatest possible strength in relation to the weight.

The lightkeeper's chamber, underneath the lantern, is reached by a winding staircase, which is supported by a central column which runs the whole height of the lighthouse, and upon which directly rests the lamp in the lantern. The risers of this staircase are of cast-iron and rest upon four tenons, which allow them to pivot freely about the central column. The treads and the railing are also of iron and can be easily and quickly removed, so that in case of a threatening storm, they can be taken from their places, and the risers, which form the frame of the stairway, can be swung around in the direction in which they will present the least resistance to the waves. Although the staircase is thus dismounted, the risers or frame still form a ladder by which access can be had to the light in case of necessity. The waves at this point frequently reach to the bottom of the light-keeper's room, which is 16 m. (52.48 ft.) above the general level of the break-water.

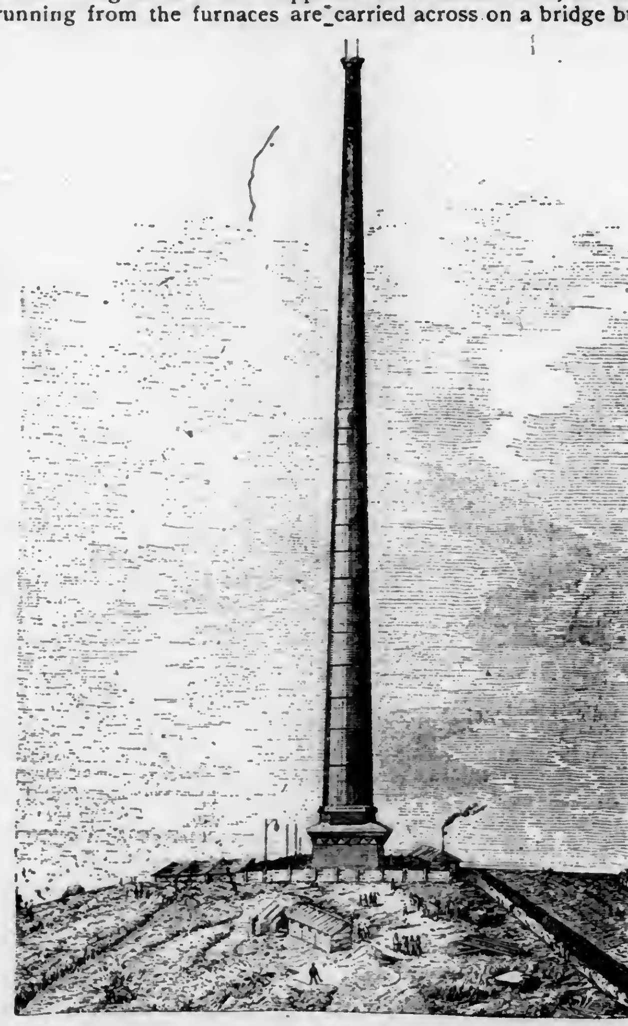
The total cost of this lighthouse was about $11,800. It was designed by MM. B. Bernard, Director of the Lighthouse Service, and A. Bourdelle, Chief Engineer of the same service.

New Steamers for the Pacific.—The Naval Construction & Armament Company of Barrow, Eng., recently took a contract to build three steamers for the Canadian Pacific Railroad Company. These steamers are to have twin screws, to be 440 ft. long and of 7,000 tons measurement, and to attain a speed of 18 knots. They are intended to run between Vancouver, the Pacific terminus of the railroad, and Yokohama.

The Canadian Pacific Company has also received bids for three steamers, 480 ft. long, 54 ft. beam, and 25 ft. draft; to have single screws and to be capable of a speed of 20 knots. These steamers are also intended to run in connection with the railroad; but on the Atlantic side, from some English port to Quebec in the summer and to Halifax in the winter. The two lines of steamers on the Atlantic and Pacific, wth the railroad, will form a through line from England to Japan and China, by which quicker time it is expected will be made than by any other route.

A Great Chimney.—The great chimney recently built at Fall River, Mass., which is 340 ft. in height, will be far surpassed by one now under construction at the Imperial Foundry of Halsbrücke, near Freiburg in Saxony, which is intended to carry the noxious gases from the furnaces to such a height in the air as to prevent any inconvenience to the surrounding country. It will be 453 ft. high, with an interior diameter of 15¾ ft. Projected and designed by the Engineer Huppner, it is built on the right bank of the River Mulde, on a hill which rises 259 ft. above the ground on which the furnaces stand, so that the top of the chimney will be 712 ft. above the works.

The base is square, measuring 39 ft. 4½ in. each way; it is 28½ ft. high, and at its top the chimney proper begins. The works being on the left or opposite bank of the river, the flues running from the furnaces are carried across on a bridge built



for the purpose, and then up the hill to the point where they enter the chimney. The total length of these flues or ducts is 3,228 ft.

The chimney is built entirely of brick. The materials are raised by an elevator, worked by an engine which is moved from time to time as the construction increases in height.

The builder of this work is Herr Heinecke. The chimney itself will cost about $30,000, and the conducting flues and other work as much more. The accompanying cut is a general view of the chimney as it will appear when finished.—*Le Genie Civil.*

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NEW YORK, MAY, 1890.

THE example set by the Vanderbilt University in Tennessee is followed by the Case School of Applied Science in Cleveland, O., which offers a free course of instruction in road management to all who desire to avail themselves of it. The instruction will consist of lectures on Location and Construction of Roads; Keeping up and Repairing Roads; Ditching and Drainage; Road Making Machinery; Improvement of Surface, including the use of Gravel, Stone, Plank, etc.; Highway Structures, including Culverts and Bridges; Cost of Earth Work and Mechanical Structures; Highway Administration, and Highway Laws. For those who desire it, additional instruction will be given in the use of engineering instruments and in drawing, and lectures on special topics connected with road-making will be given by engineers of experience. The course will begin in February, 1891, and will continue about a month.

This seems to be a very practical attempt toward the solution of the road problem, and it is to be hoped that full advantage will be taken of the offer.

THE production of pig iron continues to increase, and the April report of the furnaces shows that, as compared with March 1st, there was an increase of four furnaces in blast, with an increase in capacity of about 7,700 tons per week. As compared with last year at the same time, there is an increase of 34 in the number of furnaces in blast and of 43,300 tons in the weekly capacity. The present production, we believe, is the largest on record, but does not seem to exceed the demand.

THE breakdown of one of the engines of the *City of Paris*, which came near producing very serious results to that steamer and its passengers, has not yet been explained. From the accounts received, it appears that the low-pressure cylinder gave away in some manner, and that one engine was practically destroyed, and the other engine seriously injured by flying pieces of metal. At the same time the outboard valves were left open and the connections so damaged that they could not be closed, and in consequence a large amount of water was admitted to the engine-room compartment. It was at first supposed that the bottom of the vessel had been damaged, but later accounts say that this was not the case. It is impossible to say what part of the machinery gave away first, but it appears that the connecting-rod continued to move up and down for some time after the break took place, and that the loose end of this heavy rod did a great part of the damage. Further accounts of the accident will be looked for with interest, and it is hoped that a full statement will be given.

FIRE-BRICK FIRE-BOXES FOR LOCOMOTIVES.

ON another page we publish some comments and plans of fire-boxes, without stay-bolts, which were presented at a meeting of the German Technical Railroad Union. One of these plans shows an old boiler which was rebuilt with a fire-brick fire-box, the original casing or outside shell of the fire-box being used for the new one. The attention of the skeptics—especially the Locomotive Editor of the *Railroad Gazette*—who have oppugned this form of fire-box, when it has been proposed, is called to the evidence given by Herr Bork, Locomotive Inspector of the Thuringian Railroad, with reference to the working of this experimental boiler. Seven years' experience with this engine and boiler showed, Herr Bork says:

> That the apprehension felt that the shocks experienced on the road in service might affect the durability of the boiler were unfounded. By the use of good materials, in the first place, long life was secured for the fire-box. The boiler steamed well, and *the radiation of heat from the fire-box was not greater than in an ordinary locomotive.* The tubes and tube-sheet kept in good condition, but the latter had to be renewed after about three years' service. The reason for this was that, owing to the very rapid formation of steam on the heating surface of the tubes nearest the tube-sheet, and the use of bad water, a considerable deposit formed on the lower part of the sheet.

This difficulty, it is thought, might have been anticipated as a consequence of the inclination of the tube-sheet, as shown in fig. 5, on page 221. There was no more difficulty *in keeping the tubes tight*, Herr Bork said, *than in any ordinary locomotive.* Another boiler, shown by figs. 7 and 8, page 222, has been designed by him to overcome the difficulty with the tube-sheet, which is placed vertically in the new design, and a man-hole is provided in the under side of the barrel of the boiler, immediately in front of the fire-box, for cleaning out any deposit which may accumulate at the back end.

In commenting on this plan another engineer says:

> The simplicity of construction of these boilers is so great that their first cost *will not be much more than half* that of the ordinary locomotive boilers, while the experience had with that already in service indicates that *the cost of maintenance also will not be over half.*
>
> With this arrangement *the boiler is a simple cylinder*, to which the fire-brick lined fire-box is attached at one end and the smoke-box at the other. The only flat surfaces are the tube-sheets, which are practically so bound together by the tubes that they require little additional bracing. Already such improvements have been made in manufacture that a boiler barrel can be made of a single plate, and it is believed that the longitudinal riveting even can be dispensed with and the boiler barrel made of a single piece, welding taking the place of the rivets.

As the shell of the fire-box is not subjected to internal pressure, it need not be made as strong as ordinary fire-boxes are, and it would be subjected to little or no corrosion. It need not, in fact, be made water-tight. There would be no stay-bolts, no crown-bars, no crown-sheets, side nor end plates, and no mud-rings, all of which give incessant trouble.

If these inferences are true, they are of the most momentous importance to those interested in railroads the world

over. The apathy with which the proposal to use such boilers has been received is remarkable, and the hostility to even a consideration of the plan, which has been manifested in many quarters, is most astonishing. The fire-box of a locomotive is the most expensive part to construct and maintain. If the first cost and subsequent cost of maintenance could be reduced *one-half*, and, at the same time, as Mr. Urquhart testified, if considerably less time is required to repair such fire-boxes, and consequently locomotives with them will do more service, the subject should be worthy of careful consideration and thorough investigation by railroad managers.

THE LOCATION OF HIGHWAY ROADS.

THE agitation for reform in our highway roads, to which reference has been made from time to time, has not been dropped by any means, but has been continued in various quarters. The law passed last year in New Jersey, authorizing systems of county roads, is on trial, and promises good results; already action under it has been taken in several counties, and this year some slight amendments have been secured, to remove objections made to its workings. In New York the Governor's yearly message commended the question to the Legislature, suggesting a system of State roads, and in several other States attention has been called to the matter in various ways. In Pennsylvania a commission was appointed last year to prepare a new road law, and its deliberations were assisted by a convention called by the State Board of Agriculture, at which representatives of various bodies were present.

The Engineers' Society of Western Pennsylvania has paid particular attention to the highway question, and its reports and proceedings contain much valuable matter bearing upon it. The efforts of that society have been wisely directed toward securing improvement in local road boards and in the State laws controlling them.

There is no longer in this country any question of great National or State roads extending over long distances. The need is of systems of good roads giving every one facilities for travel to the railroad station or wharf whence his freight may be started on its longer journey by rail or water, and from which he may haul such supplies as he needs. Good local roads, to repeat, are what is most needed, and no pains should be spared in impressing upon public opinion their necessity, and in making plain to all how great a tax their absence imposes upon the community. Until this is done, no permanent improvement can be hoped for.

It is not intended to take up in this article the discussion of methods of road-making or maintenance. Important as they are, there is a point which precedes them, and that is the proper and judicious location of roads, and this point, unfortunately, has been very much neglected.

Of course, in laying out a road, the needs of local traffic and the accommodation of the residents of a district must be carefully considered, but in too many cases these have been the only points taken into account, to the total disregard of all engineering considerations, and the result has been the construction of roads so radically bad in many respects that no amount of improvement in maintenance can make them such highways as will properly and economically serve their object. This must continue to be the case as long as the present district system, which is in operation in a number of States, continues without modification. The local authority—road board, town committee, selectmen, or whatever may be the title—may understand the needs of a neighborhood, but is much too likely to be influenced by considerations of temporary expediency, local influence or position, tax rates, and other matters of the kind, while its members very seldom know anything of engineering, and are generally altogether without a realizing sense of the heavy tax which a badly-located road levies upon all who use it. The results are found everywhere in highways run upon lines which no surveyor who understands his business would consider for a moment, and which may practically double the cost of hauling to market the products of an entire district. A few illustrations or practical applications may serve to make this plain.

The accompanying rough sketches show some locations of the kind referred to; they are made from memoranda jotted down in haste, and without any pretense at exactness, but it is believed that they will show sufficiently well examples of bad work of different kinds. Doubtless every engineer—indeed, every observant traveler—who has had occasion to journey much by highway, can recall many similar cases.

To particularize, fig. 1 shows a short section of a much-traveled road in Northern New Jersey. In this case a very sharp and annoying hill is interposed, which might be entirely avoided by a slight detour. The change in plan and

Fig. 1.

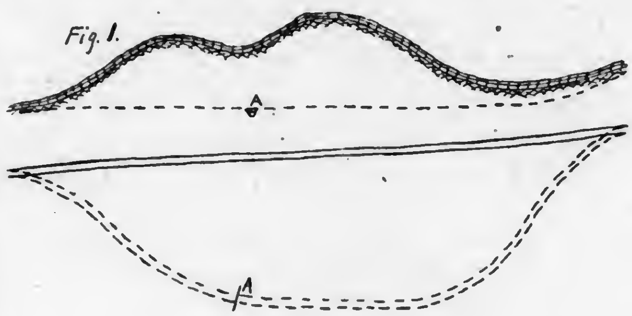
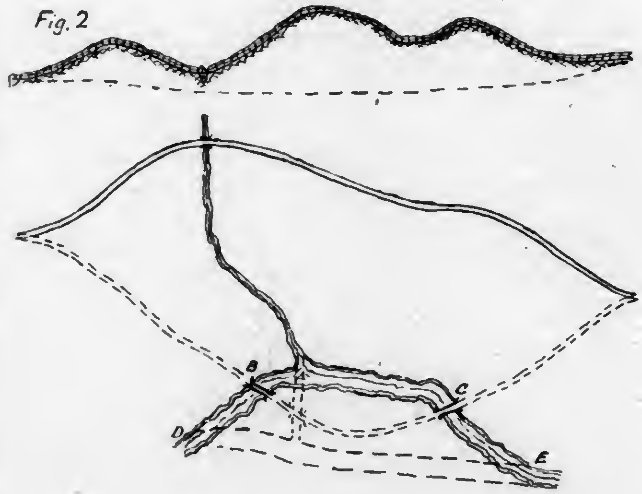


Fig. 2



grade is indicated by the dotted lines, and would not be expensive, as the only work required, beyond ordinary road-making, would be the building of a small culvert at *A*, to pass the water flowing from a spring at the foot of the hill. Why the road should have been carried over instead of around the hill in the first place, it is very hard to see, especially as it is not an air-line by any means, and there are plenty of curves at other points.

Fig. 2 shows a section of road in New York, not far from the Hudson River, where the hills seem actually to have been sought, while an easy location and grade might have been secured, as shown by the dotted lines. In this case, perhaps, there is a little show of reason, since in its changed location the road would cross a small stream at *B* and again at *C*; but the cost of the bridges would be small, compared with the advantage gained, while they might be easily avoided by digging a ditch from *D* to *E*, the expense of which would be very slight indeed.

Both these cases are notable, as they both occur in long-settled and prosperous districts, where the general condition of the ways is above the average. Both are on old roads which have been in existence for more than a century, and it is certainly difficult to understand how they have been allowed to remain generation after generation,

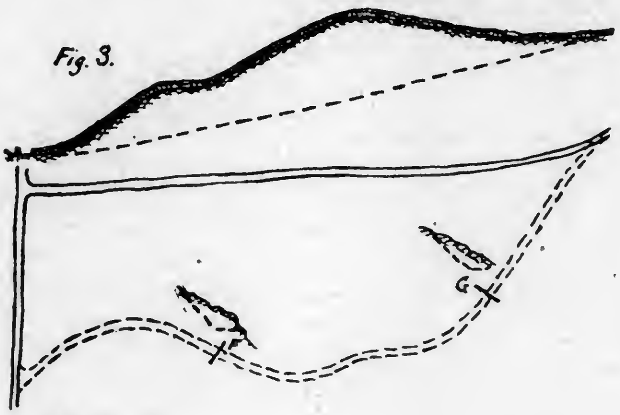


Fig. 3.

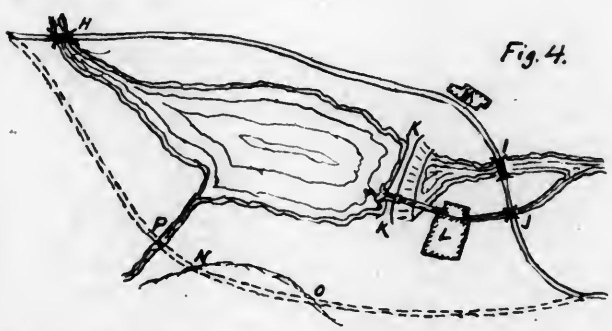


Fig. 4.

when in each case the remedy was so plain. Inquiry developed the fact that changes had been suggested, but neighborhood conservatism had been too strong for the would-be innovators, and the "old road" had been kept in its old place.

Fig. 3 shows a very steep and ugly hill on a road of considerable traffic in the Catskill region. In this case there is a rise which could not be avoided, but the much easier and even grade shown by the dotted line in the profile could have been obtained by following the location shown by the dotted lines in the plan; nor would any heavy work be required, as the hill-side could be followed everywhere except at the points *F* and *G*, where a little cutting would be needed, as shown by the sketched cross-sections; but at neither point would this cutting extend for more than 25 or 30 ft., nor be of an expensive character.

In this case the road was of comparatively recent construction, and it appears that it had been laid out to follow the boundary line between two farms. A change had been suggested, but the objection was raised that it would leave Farmer *X* a small and badly-shaped lot on the "wrong side of the road." In other words, the desire of the Town Committee to oblige a neighbor has imposed upon all the community using the road a perpetual tax, which is, perhaps, not realized because it is not paid out in money, but which is none the less an actual and onerous one.

In fig. 4 is shown a location bad, not on account of the grade, but for other reasons. On the line chosen for the road at this point there are two bridges of about 40 ft. span over the stream at *H* and *I*, and one of 15 ft. over the tail-race at *J*, below the small mill at *L*; moreover, the bridge at *I* is just below the earth dam *K K*, which is liable to fail under the pressure of any unusually heavy spring freshet. On the location shown by the dotted lines there would have been only one bridge, of 15 ft. span, over the little stream at *P*, and no extra work, except a light cutting in the hill-side, from *N* to *O*, nowhere over a few feet deep. The cost would have been less and the road safer from damage.

This last case is taken from a New England State, and here common rumor assigned a disreputable motive as partly the cause for the bad location. One reason given was the position of the miller's house at *M*, but it was also freely said that the final choice was due to the expectation of at least a majority of the Selectmen that they could "make something" out of the bridge-letting. The worst feature of it was that this did not seem to be regarded as very unusual or very reprehensible, and to an inquirer, with deep confidence in that rural virtue of which we hear so much—in the city—this was somewhat of a shock.

Now it is not the intention to say that town officers are universally or generally corrupt; doubtless many are honest and willing to act for the best interest of the community, as they see it, but the best intentions do not give a man the knowledge necessary to lay out a road or the skill to see how a bad location can be avoided.

The moral of the instances given above is that under any system of proper and intelligent supervision such mistakes could not be made, or could not be perpetuated. A county engineer, if at all competent for his position, would see at once what the true interests of the district required; his object would be to provide the best road possible and not to preserve farm fences or old boundary lines, and under proper regulations he could have no corrupt interest to serve.

The new law in New Jersey, to which reference has been made, provides for the total or partial transfer of roads from the townships to the county, and for the employment of a county engineer as executive officer. A change strongly urged in Pennsylvania is the appointment of county engineers, with power of supervision over the local boards, and of a State Engineer who shall be a general adviser and arbitrator, much in the way in which the State Superintendent of Education now acts. Both plans have advantages which can readily be seen; the adoption of one of them seems essential to any real reform.

The whole matter is so bound up with questions of local taxation and with the widely prevailing and popular, but vicious, system of "working out" road taxes, that one of the first requisites is to educate upon this subject public opinion among the classes most directly interested. This can only be done by continued effort, and it is to be hoped that the associations which have undertaken it will be encouraged to persevere in their good work.

THE INSTABILITY OF SOLIDS.

It has often been observed that the form of castings is altered by changes in temperature. This is seen in the varying and warped shapes of malleable castings after

being annealed. Another instance of this kind, where the range of temperature to which the metal is exposed is not so great, is that of double disk throttle-valves used on locomotives. No matter how carefully these are ground, and how tight they are made when the engine is new, they nearly always leak after being exposed to steam for a few hours or days. If they are then reground they will remain tight. The same experience often occurs with tubes. They may be calked so as to be perfectly tight when the locomotive leaves the shop, but will leak after being in service a short time. If they are then recalked they will usually remain tight. The reason of this apparently is in the first case that the metal in cooling, after being cast is in a state of internal strain. On being heated to a temperature considerably less than the melting-point, this strain is relaxed and a change of form results. By repeatedly heating and cooling, and thus relaxing these strains, this internal strain assumes a condition of equilibrium and the form of the casting will then not be affected by further changes of temperature.

There are many illustrations in common experience of this action, as in the case of cast-iron car-wheels, which must always be annealed, because if they are not they are liable to break in service. A curious instance of this occurred in the experience of the writer. He had in his possession a ½-in. hardened steel cylindrical gauge which fitted *perfectly* into a ring of the usual form made for such gauges. This was kept in a morocco case lined with silk and plush, and kept in the editorial desk where no one had access to it but the writer. It was never used excepting to exhibit it as a curiosity, and was not used in that way more than perhaps half a dozen times in all. After resting quietly in the desk for somewhat less than a year, it was found that the plug or ring, or both, had in some way changed their dimensions so that the one would shake sensibly inside of the other. There is no doubt that they fitted each other at the beginning of the period named, as near perfectly as could be ascertained by the sense of feeling, and it is equally certain that they did not fit each other at the end of the time referred to. There is no probability that they were handled during that time by any one but the writer, or by some one in his presence, or that they were tampered with by any other person. Now what is the explanation ? There can be no doubt that metal exposed to high and then to low temperature changes both its form and dimensions, as in the case of locomotive tires, which will be somewhat smaller after being heated " cherry-red " and cooled. There is every reason to believe that much lower ranges of temperature will alter the form and dimensions of metal, which changes can be recognized only if we have sufficiently delicate means of measuring them, as we have in the case of a cylindrical gauge and its ring. In other words, the ordinary atmospheric changes of temperature affected the form of the ring or the dimensions of the plug, but to so small an extent that it could not be detected by any ordinary means of measurement. The great accuracy with which they were made to fit each other gave the means of discerning the change.

A writer, Mr. Herbert Tomlinson, in a recent number of *Nature*, in commenting on the permanent ascent of the zero-point of a mercurial thermometer, after prolonged heating to a high temperature, has given some interesting and valuable observations on this subject. He says :

" Researches on the effects of stress on the physical properties of matter have convinced me that the molecules, not only of glass, but of all solids which have been heated to a temperature at all near their melting-point, are, immediately after cooling, in a state of constraint, and that this state can be more or less abolished by repeatedly heating the solid to a temperature not exceeding a certain limit, and then allowing it to cool again (it is not only the heating but the cooling also that is efficacious). It appears that the shifting backward and forward of the molecules, produced by this treatment, enables them to settle more readily into positions in which the elasticity is greatest and the potential energy is least.

This "accommodation" of the molecules, as Professor G. Wiedemann and others have called it, is, as one might suppose, attended with alterations of the dimensions and other physical properties of solids, and is not confined to the release of molecular strain set up by thermal stress, but is extended to the strain set up by any stress whatever. As years roll on, the time of vibration of a metal pendulum gradually alters (and so, no doubt, do the lengths of our standard measures), the bulb of a thermometer diminishes in volume, a steel magnet parts with more or less of its magnetism, a coil of German-silver wire gains in electrical conductivity, etc. The changes in all these cases would probably be far less than they actually are if the temperature throughout the whole time could be maintained constant ; but this last is not the case—heating and cooling goes on more or less every day. We may assist the effect of time by artificially increasing the range of temperature, but it would appear that we must not exceed a certain limit of temperature, which limit depends partly upon the nature of the substance and partly upon the stresses that are acting upon it at the time. Thus, the internal friction of a torsionally oscillating iron wire which has been previously well annealed may be enormously diminished by repeatedly raising the temperature to 100° C., keeping it there for several hours, and then allowing it to fall again. The amount of diminution of internal friction depends upon the nature of the wire, and on the load which there is at the end of it (if the load exceeds a certain amount, the friction is increased instead of diminished). In attempting to "accommodate" the molecules in this manner the heating must, at any rate in some cases, be prolonged for several hours, and the substance should then be allowed to remain cold for a still longer period.

These principles appear to have a practical and an *important* application in mechanical engineering, where permanence or great precision is required in machinery. Thus, complaint is constantly made by the manufacturers of chilled cast-iron wheels, that it is impossible to keep the chill-molds true and round. These molds are frequently exposed to the temperature of molten iron and then cooled, and, consequently, in workshop phraseology they " get out of true." If the principle laid down by Mr. Tomlinson, that the constraint of such a solid " can be more or less abolished by repeatedly heating it to a temperature not exceeding a certain limit, and then allowing it to cool again," is correct, the obvious thing to do would be to anneal all chill-molds for car-wheels and other castings repeatedly before they are turned. If the theory above set forth is sound, chill-molds would remain true a much longer time if thus treated before turning than they will without being annealed. At present the practice is to turn them first and *then* change their shape. The suggestion is that their shape should be changed and made permanent *first* and they should then be turned. It is to be hoped that some wheel-maker will make a test of this suggestion and report the results.

The principle has, however, a much more extended application. It seems probable that if locomotive throttle-valves and the upper portion of the steam-pipe which forms the valve-seats were annealed *before* being finished, they would give much less trouble than they now do from leaking. In fact, it would seem to be a good plan to anneal all cast-iron steam-pipes before putting them into locomotives. Those in the smoke-box, especially, are exposed to high temperature, and are of such a form as to be very liable to change their shape by alternate heating and cooling.

It is also probable that a much higher degree of precision could be attained and *maintained* in machinery, such as lathes, planers, drills, and other machine tools, if their frames, beds, etc., were made permanent in form by annealing them before being finished.

AN ITALIAN LOCOMOTIVE.

THE *Railway Engineer* (London) for April contains engravings and a description of a locomotive which was built for the Southern Railroads of Italy, and was exhibited at the Paris Exhibition. It is referred to on account of its close resemblance to the common type of American passenger locomotives. It has four coupled drivers and a four-wheeled truck. The main driving axle is in front of the fire-box, and the trailing axle is at the back end below the fire-box. The cylinders are outside with the steam-chest on top. The valve-gear is of the ordinary shifting-link type connected to a rocker-shaft in the usual manner. The truck is suspended on swing-links and has long equalizing levers and a single spring between the axles. The cylinders are bolted to a heavy bed-casting. Even the cab is of the American style. Both the truck and the engine frames are made of plates which enables the fire-box to be several inches wider than is possible with American frames if it is placed between them. Evidently Signor Cavaliere E. Riva, the Locomotive and Carriage Engineer who designed the engine, recognizes good things when he sees them.

NEW PUBLICATIONS.

ELEMENTARY MANUAL ON STEAM AND THE STEAM-ENGINE, and A TEXT-BOOK ON STEAM AND STEAM-ENGINES: BY PROFESSOR ANDREW JAMIESON. London, England; Charles Griffin & Company.

The first of these books, the author says in his preface, was written expressly for apprentice engineers and elementary or first-year students studying Steam and the Steam-Engine. The second, which is a new edition of a work published some years ago, is the result of gradually improved lectures delivered on these subjects to the students of the Glasgow College of Science and Arts. Extensive and important additions, both to the text and the illustrations, the Author says, have been made in this new edition.

The three introductory lectures, of the first of these books, is on Elementary Mensuration; the seven which follow are on Heat, which are succeeded by three relating to the Temperature and Pressure of Steam. It is only when we reach the XIV lecture that the Steam-Engine itself is discussed. This lecture gives a general idea of the relative positions and motions of the chief parts of a steam-engine, and is succeeded by lectures on the Slide-Valve; the Indicator; Condensing and Non-Condensing Engines; Simple and Compound Engines; General Description of a Marine Engine; Details of Engines; Various Kinds of Valves; Condensers; Crank-Shafts; Boilers, and Boiler Mountings.

To each lecture is appended a series of questions on the subjects discussed.

The descriptions are written in a clear and simple style so that they can be readily understood, but some of the mathematical parts will probably appear rather formidable to an "apprentice engineer" whose education has not advanced farther than reading, writing, and ciphering, and who is shaky in square roots, mystified by Greek notation, and reduced to despair by algebraic formulæ.

The portion of the book relating to thermodynamics is written very clearly, and probably it would be difficult for a student to find a book from which he can get a good idea of the subjects explained so easily as he can from this Elementary Manual. The explanation of the differences between simple, compound, triple, and quadruple-expansion engines is also very clear. The description of a modern marine engine cannot be commended so highly. The engravings do not show the construction of the engine as distinctly as they might. In writing an elementary technical book of this kind skill in mechanical drawing, as Nasmyth said, "is one of the highest gifts in conveying clear and correct ideas, as to the forms of objects, whether they be those of a simple and familiar kind or of some mechanical construction." An author of a book of this kind needs this gift quite as much as he needs the ability to write clearly; and the lucidity of his explanations will depend very largely on the skill and ingenuity with which his drawings and illustrations are adapted to represent the subjects and objects to be explained.

The descriptions of the mechanical construction of the different parts of engines and boilers are all written very plainly, but they are confined, almost entirely, to one class, and in fact, to a single example of a class of engines.

The Text-Book, whose title is given above, contains most of the matter in the "Manual," the first three chapters on Mensuration in the latter book being omitted in the "Text-Book," two chapters on the early history of steam-engines being substituted instead of the Mensuration. Any one who has had occasion to look over many books on the Steam-Engine must have been impressed with the great waste of printers' ink, paper, and money, which has been entailed by the mistaken sense of duty, which nearly all authors of books of that kind seem to feel, and which leads each of them to repeat in each book which appears what has been written and printed again and again in earlier publications. If such a history was essential in understanding the modern steam-engine, it would be some reason for republishing it, but it does not do even that, but rather has the reverse effect by first filling the student's mind with a number of ideas of which he must then divest himself—if he can—as soon as he understands them. If an author of such a history would make some original researches, there might be some excuse for publishing it—at the end of a treatise. But they never seem to spend any time or effort in this direction, and they always begin their books with the history. A boy learns about a locomotive by seeing modern engines on railroads. When his curiosity is excited he begins to inquire what it is "that makes it 'go.'" Then he finds out how the steam gets in and out of the cylinders, and how the pistons turn the wheels, and so on, step by step, until he gets a tolerably complete understanding of the construction and operation of the machine which he sees at work every day. It would be difficult to induce such a boy to read up the history of the locomotive, but he will devour with avidity all the information within his reach which will tell him how a locomotive is started and stopped, and why one of them will pull more or run faster than another.

To begin an elementary treatise with a history is turning the natural order of education upside down. If the one which has been the object of the preceding criticism was relegated to an appendix or omitted altogether, it would improve the book materially.

In the "Text-Book" the lecture on The Distribution of Steam is supplemented with a description of Zeuner's diagram of valve-motion. That on the Indicator has a description added of the method adopted to combine the diagrams of the high and low-pressure cylinders of multiple-expansion engines. Different forms of brakes are also illustrated and described in a succeeding lecture. A lecture on the action of the crank and one on stationary engines follows. These are succeeded by another history of marine engines, descriptive of the various types which have been used. Different kinds of compound engines are also described. In the part relating to boilers a variety of

types are illustrated and the details of construction explained. The last Lecture is on locomotives—with a history—and a folded plate and description of a modern locomotive by Messrs. Dubs & Company.

In these days of multiplicity of books, it may well be questioned whether an author is justified in making a new book by merely amplifying an old one. Economy of human mental effort must certainly be studied more in the future than it has been in the past, and a useless multiplication of books or unnecessary increase in their size is, from a critic's point of view, inexcusable.

Professor Jamieson's two books are excellent elementary treatises on the marine engine, but they should be boiled down to one. He writes with great clearness, and a student cannot find anywhere better explanations of portions of the theory or descriptions of the construction of some of the parts of marine steam-engines than he will find in these two little treatises, which are recommended to students and mechanics generally who want information with reference to the important and interesting subject of which they treat.

Slide-Valve Gears; An Explanation of the Action and Construction of Plain and Cut-off Slide-Valves: by Frederick A. Halsey. New York; the D. Van Nostrand Company.

This little book is a treatise on Slide-Valve Gears, used on stationary engines, especially on the high-speed engines which are now so generally used. It discusses first the action of an ordinary slide-valve with a fixed eccentric, and then describes the method of analyzing it by means of the Bilgram diagram, which the Author prefers to that of Professor Zeuner. In the preliminary description the influence of the connecting-rod is ignored, but after the application of the diagram is explained, the methods of correcting the effect of the connecting-rod are elucidated.

The various kinds of slide-valves in use on modern high-speed engines, such as the Straight Line Valve, the Woodbury, Armstrong, Rice, Armington & Sims, Ide, and the Giddings valves, are illustrated by engravings, and their operation is explained. The application of shifting and swinging eccentrics to these valves, and the methods of equalizing the lead, points of cut-off, and exhaust are fully described.

Part III is devoted to the slide-valve with independent cut-off, and the method of analyzing it with the Bilgram diagram.

The Author says that the book "has been written with the aim of making it intelligible to any one who might be willing to make a serious effort to understand it. High authority exists for a mathematical treatment of the subject, but with this the Author has no sympathy. Designing a valve-gear is essentially a drawing-board process, and a mathematical treatment of it is simply an uncalled-for use of heavy artillery. The graphical treatment is therefore adopted throughout."

The development of high-speed engines has been attended with the introduction of many refinements in the design and construction of valve-gear. Descriptions of these—when they have been described—are scattered through trade catalogues and technical papers, and are consequently not easily reached by students or others who want information concerning this subject. The little book of Mr. Halsey is therefore a timely one. Generally it is written in a very clear style. The explanation of the Bilgram diagram is, however, not as plain as it might be, and it will puzzle many readers to get from it a complete idea of the methods of its application. The engravings—mostly diagrams—are made by the "wax process," and are excellent. It is a pleasure nowadays to get a technical book to review which is not loaded down with sloppy "process" cuts of all degrees of badness, which are often execrable copies of illustrations which have long since attained their majority.

Noiseless Motors and Steam Street Cars for City and Suburban Railroads. Philadelphia; issued by the Baldwin Locomotive Works; Burnham, Parry, Williams & Company.

This is an illustrated catalogue of the small locomotives and steam cars made by the Baldwin Locomotive Works for street and local railroads. The catalogue is preceded by an interesting chapter or paper summing up the advantages of such motors and the reasons in favor of their use, as compared with cable systems, electric cars, etc.

It is, perhaps, hardly necessary at this day to argue on the superiority of mechanical traction over horse-power for street railroads. The cable, the electric motor, and the steam car have each their advantages, and there is a wide field open for each in this country. While they are rivals to a certain extent, there is no doubt that all three can find a place.

The catalogue concludes with a list of some 70 roads on which these steam motors are in use, and a table giving results of operations on a number of lines.

The Traffic Capacity of the New York & Brooklyn Bridge Railroad: by G. Leverich, C.E. Brooklyn, N. Y.; published for the Author.

This is a very interesting study of the Brooklyn Bridge Railroad, which is one of the greatest passenger carriers in the world, and is written by an engineer who has had exceptional opportunities of studying the subject from his long professional connection with the Bridge. The regular average number of passengers is now over 100,000 per day, and as many as 159,259 have been carried in a single day, while the traffic is steadily increasing. At present it is obstructed and at certain hours of the day passengers are much inconvenienced by insufficient terminal facilities. Mr. Leverich seeks to show in his pamphlet what is the full capacity of the road and how it may best be utilized; and he presents carefully studied plans for new terminal stations. The question is a pressing one, and an attempt to improve the present condition of affairs deserves careful attention, especially when it is so well presented as in the present case.

Twenty-first Annual Report of the Board of Railroad Commissioners of Massachusetts, for the Year 1888–89: George G. Crocker, Edward W. Kinsley, Everett A. Stevens, Commissioners. Boston; State Printers.

This report usually receives much attention and contains valuable suggestions in relation to railroad management. It is hardly as long as usual this year, but has nevertheless much that is suggestive. The principal subjects to which reference is made this year are Grade Crossings, Stations, Boston Terminal Stations, and Electric Street Railroads. The first named question receives particular attention on account of the number of accidents to persons resulting from the crossing of highways by railroads at grade; but very little progress has so far been made toward separating them, even in Massachusetts.

The Coal Trade, 1890: by Frederick E. Saward. New York; published by the Author.

This is the seventeenth yearly number of this standard work, and there is, perhaps, very little more to be said of it than that it is as full of information, as carefully prepared, and as indispensable to all interested in the trade as its predecessors. As Editor of the *Coal Trade Journal* Mr. Saward has shown a thorough understanding of the subject, and a knowledge of the re-

quirements of the trade, which are equally apparent in his yearly manual. The tables given are as complete as they can be made with our present methods of gathering statistics, and they are presented in a clear and excellent way.

Traite General des Tarifs de Chemins de Fer: par F. Ulrich, Conseiller Intime au Ministere des Travaux Publics de Berlin. Paris, France; Baudry & Compagnie.

This is the French edition of a very elaborate work on the tariffs and rates of the railroads in the different countries in Europe, written by Herr Ulrich, whose position in the Ministry of Public Works at Berlin has given him full opportunities of studying the subject, of which he has availed himself with German thoroughness.

The book is divided into two parts, the first being a general treatise on railroad rates and the principles which should govern them; their relations to private business and to the public interest. The second treats of the development of the systems adopted in the various European countries; of the methods upon which tariffs are made and changed, and of the laws and governmental regulations in relation to them.

The book does not deal with rates in this country, but to those who study the subject it will be a matter of much interest to compare European methods with our own, and especially to note where they have differed from ours and where they have approached them. Some reasons, both for the resemblance and the divergence can be found in Herr Ulrich's book.

It would be a difficult matter to write a similar one on American rates, but if some one who was qualified for the task would undertake it, such a book would be of value and might perhaps lead to the adoption of better systems than we have yet had.

BOOKS RECEIVED.

Spon's Tables and Memoranda for Engineers: by J. T. Hurst, C.E. Tenth Edition. New York; E. & F. N. Spon. This little book contains a number of convenient reference tables, such as an engineer is most likely to need in a hurry, and is of a size ($1\frac{3}{4} \times 2\frac{5}{8}$ in.) convenient to carry in the vest pocket.

Air Brake Practice: by J. E. Phelan. New York; published by the *Locomotive Engineer.* This book is received too late for proper review and comment, which will be given hereafter.

The South's Redemption from Poverty to Prosperity: by Richard H. Edmonds. Baltimore; published by the *Manufacturers' Record* Company (price, 25 cents). This pamphlet is a republication of a special edition of the *Manufacturers' Record* issued in December of last year, with additional statistics, bringing the reports down to the close of the year. It has been thought that the matter in this shape would be more convenient for use and for subsequent reference. It presents an account of the recent progress of the South in manufacturing and industrial enterprises, showing a very remarkable record.

Providence Terminal Facilities: the Accepted Plan for their Improvement. Providence, R. I.; reprinted from the Providence *Journal.*

Occasional Papers of the Institution of Civil Engineers. London, England; published by the Institution. The present issue includes papers on Triple-Expansion Engines and Engine Trials, by Professor Osborne Reynolds; Water-Tube Steam Boilers for Marine Engines, by John I. Thornycroft, with abstracts of the discussions on both papers.

Transactions of the American Institute of Electrical Engineers; Review of the Modern Theories of Electricity: by Professor W. A. Anthony. New York; published by the Institute, R. W. Pope, Secretary.

Reports from the Consuls of the United States, Issued from the Bureau of Statistics, Department of State: No. 113. February, 1890. Washington; Government Printing Office.

Fourth Report of the Association of American Railway Accounting Officers: New Orleans Meeting, January 22 and 23, 1890. Chicago; published by the Association, C. G. Phillips, Secretary.

Proceedings of the Second Annual Convention of the Iowa Society of Civil Engineers and Surveyors held at Des Moines, Iowa, December 27 and 28, 1889: Seth Dean, Secretary. Glenwood, Iowa; published for the Society.

The Sewer Gas Question: by E. S. McClellan, M.D. New York; issued by the Du Bois Manufacturing Company.

Comparative Value of Heart and Sap Pine: by Richard Lamb, C.E. Relative Strength of Heart and Sap Pine: by W. L. Brown. Wilmington, N. C.; issued by the Authors.

1. Electric Transmission of Power; Mill Work. 2. Facts about the Sprague Electric Stationary Motors. 3. The Sprague Electric Railroad System. New York; issued by the Sprague Electric Railway & Motor Company. These three pamphlets contain illustrated descriptions of a number of applications of the electric motor.

The Ventilation of Buildings: by Alfred R. Wolff, M.E., Consulting Engineer. New York; published for the Author.

Sprague Electric Equipment Company: Catalogue of Electric Railroad Apparatus and Supplies. Chicago; issued by the Company.

Catalogue and Price Lists of the Brown & Sharpe Manufacturing Company: Machinery, Gauges and Tools for Accurate Measurement. New Edition, 1890. Providence, R. I.: issued by the Company.

Kalamazoo Railroad Velocipede Car Company: Illustrated Catalogue. Kalamazoo, Mich.; issued by the Company.

Richards' Patent Open-Side Planing and Shaping Machine: Illustrated Catalogue and Description. Philadelphia; published by Pedrick & Ayer, Manufacturers.

ABOUT BOOKS AND PERIODICALS.

The Technology Quarterly for February has an interesting article on the Study of Statistics in Colleges and Technical Schools, by Francis A. Walker, and several other papers of much technical value.

In the Century for April Major J. W. Powell continues his series by an article on the Non-Irrigable Lands of the Arid Region. A paper of much interest just now is Suggestions for the Next World's Fair, by M. Georges Berger, who was Director of the last Paris Exposition and so speaks with authority.

The Popular Science Monthly for April has two articles which will be read with interest—On the Natural Inequality of Man, by Professor Huxley, and on a Lesson in Co-operation, by C. N. Ousley. The article on Science in the High School, by Professor Jordan, deserves a careful reading.

The Electric Railway of To-day, by Joseph Wetzler, in Scribner's Magazine for April, is a very interesting account of what has actually been done in the application of the electric motor to street cars. It describes the various systems in use clearly and without any undue bias toward any one system and explains the main principles upon which all are based.

In the Journal of the Military Service Institution for March there is the first part of an exhaustive article on the Develop-

ment of Submarine Mines and Torpedoes, by Lieutenant James C. Bush; articles on the Instruction of Non-commissioned Officers, by Lieutenant H. C. Carbaugh; Military Instruction of Our Youth, by Lieutenant Frank Eastman; India, China and Japan, by Captain S. M. Mills; Mackenzie's Last Fight, by Captain John G. Bourke. The number also contains some interesting translations and reprints from foreign journals.

In the March number of the JOURNAL of the New England Water-Works Association there is published a long and exhaustive paper on Fire Streams, by John R. Freeman, giving an account of a number of experiments made, with practical tables based on the results obtained. To those concerned it is a very interesting and valuable article.

In the March number of HARPER'S MAGAZINE General Wesley Merritt described the Army of the United States, and in the April number he gives some idea of the work it has to do in a graphic and interesting account of Three Indian Campaigns.

The WESTERN ENGINEER for March, published by the Pond Engineering Company, has two valuable papers, one on the Steam-Engine, by F. E. Sickles, the other Boiler Feed Pumps, by Frank H. Pond.

In OUTING for April the military articles are continued by one on the Alabama State Troops. There are a number of others of interest to all who enjoy out-door sports.

The April ARENA has several controversial articles which can hardly fail to call out sharp replies. Discussion is the basis of the new magazine, however, and the free statement of views will be welcomed.

A CAUSE OF BOILER EXPLOSIONS.

(Abstract of paper read before the Scientific Society of Bridgeport, Conn., by Mr. Frank G. Fowler.)

THE frequent occurrence of boiler explosions under circumstances which make any explanation of the causes difficult or apparently impossible, has led to the putting forward of many theories, most of which are based entirely upon assumptions or hypotheses, and not on actual facts or experiments. In this paper there is presented a theory founded on some experiments of a very remarkable character, the results of which seem to contradict all our accepted ideas.

Briefly stated, the experiment—which has been repeated many times, under circumstances which seem to preclude all possibilities of mistake—is this. A small closed boiler, partially filled with water, in about the same proportions as ordinarily used in service, is heated by a flame until the pressure rises, say, to 40 lbs. Now this boiler being suddenly disturbed or reversed in position, without any additional heat being applied, the pressure is at once more than doubled—in the case actually described rising to 82 lbs. This rise in pressure, although taking place suddenly, is not momentary only, but the gauge continues to show the higher pressure for some time, falling gradually, but slowly.

Now further, this sudden change in pressure occurs when the boiler has been filled with water from any ordinary source—as hydrant, spring, rain or river water—and no steam has been allowed to escape. But if the water has been "de-aerated"—that is, if steam is allowed to escape, forcing out and carrying with it what air may have been enclosed in the boiler, and the agitation or reversal of the boiler is then repeated, the rise in pressure will be very small; in the case actually noted and described, the change was only from 40 to 42 lbs.

It may be noted that this experiment may be very easily and simply made by using a piece of iron pipe with a cap screwed on each end and provided with a steam gauge. It has been made in this way a number of times, and if strong pipe is used very high pressures may be safely applied. In one case on record the pressure rose, on reversing the tube or boiler, from 85 lbs. to 172 lbs., recorded by a reliable gauge.

Now it may be safely said that a boiler fails or explodes because the pressure within it is greater than its strength will bear. Where it fails from any local defect, such as a corroded plate, bad workmanship, lack of proper bracing or the like, there are generally premonitory warnings, and the failure, moreover, is usually only partial and leaves traces by which the cause can be detected. But where a boiler gives way at once, and there is no sign of any defect, it may be assumed without much doubt that there has been excessively high pressure.

The experiments under consideration seem to show that this excessive pressure may be suddenly developed in a way not clearly understood. By the accepted laws the pressure of steam cannot be increased without an addition of heat, and the pressure in a boiler could not rise from 40 to 82 lbs., as stated above, without an increase in temperature, which has certainly not been apparent in the experiments made.

To account for the results, therefore, the Author believes that the increase in pressure noted is due to the air and other gases conveyed into the boiler with the water, and that when these gases are suddenly commingled with the water by any disturbance of the boiler, it is their expansion which raises the pressure and produces destructive results. In other words, the pressure in a boiler may be raised far beyond the limit of safety without warning, without the application of additional heat and in a way which will leave no trace of its cause.

To corroborate this theory, the following points may be noted:

1. Many explosions take place at the moment when an engine is started—that is, when the throttle valve is opened and steam is drawn rapidly from a boiler which had been up to that time entirely closed. Here the conditions approach those of the experiments—that is, the boiler still contains the air and other gases which it held when the fire was started, while the opening of the throttle produces a disturbance which, while less violent than a reversal of the boiler would be, is sufficient to commingle the gases as above stated.

2. The class of boilers in which explosions occur more frequently than in any other is the "rotary digester" used in many mills. In these boilers there can be no suspicion of overheated crown-sheets, low water or similar causes, as they are heated by steam and not by the direct application of fire. There is a continued introduction of water containing air and gases, and the boiler itself is in constant rotation, so that those gases are thrown out and liberated from the water.

3. The fact that boilers seldom explode from "unexplained" or "mysterious" causes when the engine which they supply is working steadily. Under these conditions the water in them is at least partially de-aerated by the drawing out of the steam; for while some air and other gases are introduced with the feed-water, the quantity in the boiler is very much less than when steam is first raised by starting a fire under a boiler which is partly filled with air. Moreover, explosions in marine boilers, which are fed with water from the condenser, or distilled water, are almost unknown.

4. Experiments made by heating closed boilers until they exploded showed that the destructive effects of the explosion are considerably greater where the boiler is filled, say two-thirds, with ordinary hydrant water and the rest with air, than where the water has been de-aerated by allowing steam to escape, carrying with it the confined air and gases, before the boiler was closed and heated to the exploding point.

It may be stated that the Author has not based his theory upon a single experiment, but upon a series of experiments repeated many times, under conditions varying as much as possible, and continued so long as to prevent any possibility of mistake; and upon these experiments he bases his explanation of those explosions which are called "mysterious." That the results of the experiments are of a very remarkable character cannot be denied.

A COMPOUND PASSENGER LOCOMOTIVE.

THE accompanying illustration, from the London *Engineer*, is a general view of one of five compound locomotives on the Worsdell & Von Borries system, recently built for the Northeastern Railway of England, and now in use on the express passenger trains of that line. Fig. 2 is a front view of the engine, showing the arrangement of the cylinders. The engine, as will be seen, is inside connected, and has a single pair of drivers.

The boiler is of steel, the barrel being 51 in. in diameter and 10 ft. 7 in. long. The fire-box is of copper, and is 6 ft. 3½ in. long, 3 ft. 2¾ in. wide, 6 ft. 3½ in. deep at the front end and 5 ft. 3½ in. at the rear end. There are 203 tubes, of brass, 1¾ in. diameter and 10 ft. 11 in. long. The fire-box heating surface is 123 sq. ft. and that of the tubes 1,016 sq. ft., making a total of 1,139 sq. ft. The boiler is built to carry 200 lbs. pressure, but 175 lbs. is the working pressure generally used.

The driving wheels are 7 ft. 7¼ in. in diameter, and the trailing wheels 4 ft. 7¼ in.; the truck wheels are 3 ft. 7¼ in. All the wheels are of cast steel, with steel tires. The truck axles have journals 6 × 9 in., and the trailing axles 7 × 11 in. The crank axle is of steel, with journals 8 × 9 in., and the crank bearings are 8¼ in. in diameter and 5 in. long.

The high-pressure cylinder is 20 in. in diameter and the low-pressure cylinder 28 in., both being 24-in. stroke. The small cylinder has steam-ports 1¾ × 17 in. and exhaust-ports 3½ × 17 in.; for the large cylinder the steam-ports are 2 × 20 in. and the exhaust-ports 3½ × 20 in. Joy's valve gear is used, the valve for the high-pressure cylinder having 1⅛ in. lap, 0⅛ in. inside clearance, 0$\frac{3}{16}$ in. lead and 4⅝ in. maximum travel; the low-pressure valve has the same lap, inside clearance and lead, and 5⅝ in. maximum travel. The piston-rods are 3½ in. in diameter, and the connecting-rods 6 ft. 1 in. between centers.

The peculiar arrangement of the cylinders is made necessary by the great size of the low-pressure cylinder and the narrow space between the frames. The steam-chests are placed outside, as shown in fig. 2.

The total weight of the engine in working order is 104,550 lbs., of which 35,670 lbs. are carried on the truck, 39,760 lbs. on the driving-wheels and 29,120 lbs. on the trailing wheels.

The frames are of the plate type, and are of steel 1 in. thick; they are 4 ft. apart. The truck wheels are 6 ft. 6 in. between centers. The distance from the center of the truck to center of driving wheel is 10 ft.; center of driving to center of trailing wheel, 8 ft. 8 in. The total length of the engine is 28 ft. 8 in.

The tender, which is carried on three pairs of 45-in. wheels, has a total weight, loaded, of 89,700 lbs.; it can carry 3,940 galls. of water and 4 tons of coal. The great tank capacity is necessary, as these engines have to make the run from Newcastle to Edinburgh, 125 miles, without stopping.

As to their performance in service, it is stated that with these engines the saving in water as well as in fuel is from 18 to 20 per cent. as compared with the non-compound engines on the same service. As a matter of fact, the consumption of all the compound passenger engines working the same relative trains with the non-compound engines averaged, during 12 months, a net saving of 22 per cent. in coal.

In designing these engines the greatest consideration has been given to all the working details, so that the long distance can be run at the high speeds required with as little extra need for attention on the part of the men in charge as possible, and every facility has been provided for their ready control. The personal comfort of the enginemen has also been attended to, so that they can perform the duties that devolve upon them under the most favorable circumstances. The first of these engines, No. 1,517, was put to work in October last, and this, with the other three, has been working the fast passenger traffic between Newcastle and Edinburgh regularly, the number of vehicles varying from 10 to 22; in either case these engines have no difficulty in running within time.

On one occasion a trial was made between Newcastle and Berwick with a train of 32 empty carriages, the distance being 67 miles, and the total weight of train 270 tons; the time was 78 minutes, or three minutes less than that of the regular Scotch express, and with the heaviest loads it is quite unnecessary to provide an assisting engine.

The consumption of coal is, indeed, much lower than anticipated. At the end of October, No. 1,517 engine averaged 26.4 lbs. of coal per mile. These engines steam well and run exceedingly steady. With a special train of 18 six-wheeled carriages a speed of about 90 miles per hour—the highest on record by several miles—was obtained, and at that speed there was not the slightest inconvenience in moving about on the foot-plate or front end of the engine.

It may be stated that several more engines of the same

COMPOUND PASSENGER LOCOMOTIVE, NORTHEASTERN RAILWAY, ENGLAND.

pattern are now under construction for the Northeastern Railway, and that there are now in use on that road 32 compound passenger engines and 162 compound engines

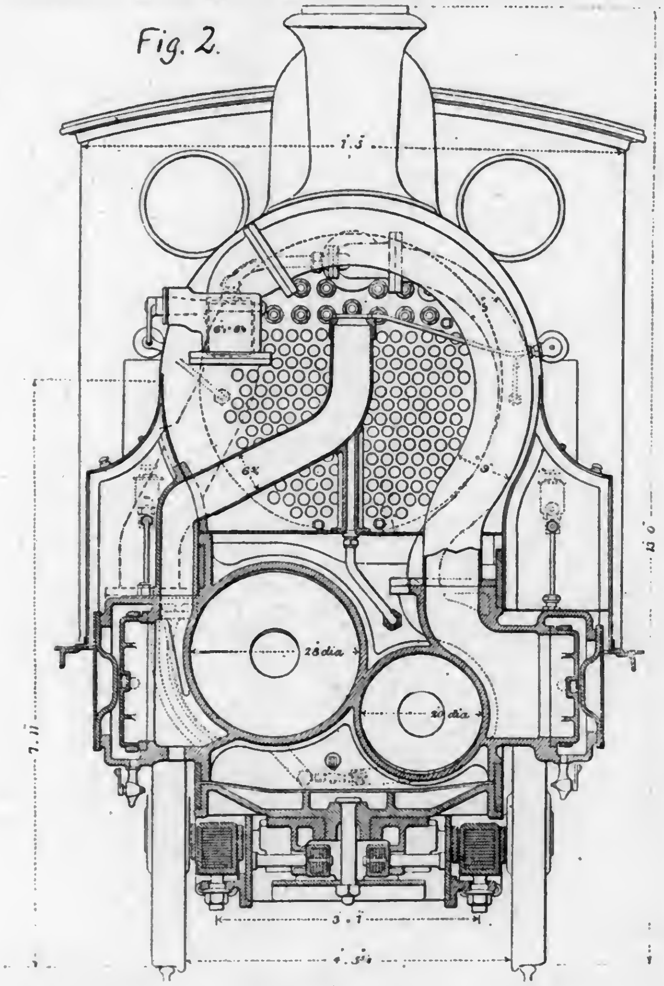


Fig. 2.

in freight service. In all about 600 compound locomotives of the Worsdell & Von Borries type have been built up to the present time.

INTEROCEANIC COMMUNICATION BY WAY OF THE AMERICAN ISTHMUS.

By Lieutenant Henry H. Barroll, U.S.N.

(*Continued from page* 173.)

VIII.—THE SYSTEMATIC SURVEYS BY THE UNITED STATES.

The continued prosperity of the West and the Northwest during the four years of Civil War caused the question of an Interoceanic Canal to be taken up with vigor after peace was restored.

Various "best routes" were claimed, generally by individuals who had obtained "concessions" from the Central American States.

England, France and the United States had each, during the first half of the nineteenth century, contributed to the work of exploration and extending geographical knowledge of the Isthmus; but to the latter nation rightly belongs the honor of having fully and clearly demonstrated, since the war, by hundreds of lines of survey, the best and most feasible lines of transit.

Humboldt had suggested that a party, fully equipped, be started along the backbone of each ridge, and thus, by deliberate surveys, prove where existed the lowest depressions; and then to devote attention only to these points. But the reverse of this was the plan which was finally adopted.

Lieutenant (now Rear-Admiral) Daniel Ammen, U.S.N., became attracted by a passage in the report of Lieutenant Strain with regard to that ill-fated expedition, which passage stated that he had heard, or thought he had heard, the sound of the evening gun aboard the *Cyane*, the vessel that he had four days previously left.

Acting then upon the supposition that the sound-wave would follow the line of least resistance, Ammen, in 1856, projected and presented to Mr. Toucey, then Secretary of the Navy, a systematic plan for a survey of the Isthmus of Darien, accompanied by a request that he be allowed the necessary means to prosecute the work.

Ammen based his system on the axiom that *the bed of a stream or river indicates the line of lowest levels in the whole basin drained by that stream*; and he was convinced that by following up the several streams he would thus find lines of lowest levels, and then, avoiding the higher divides, might confine the more minute explorations to the lower passes.

Lieutenant Ammen's request was not granted; and his sea duties calling him to the Pacific, he had no further chance to pursue the subject until 1860, when he read before the American Geographical Society a letter on this subject, in which he especially called attention to the interminable forests, with their network of matted vines, through which the cutting of a bare walking trail was a task of such difficulty; all of which could be lessened, if not avoided, by running the surveys along these natural water-courses. He also suggested the construction of dams across ravines, by which the line of canal cutting would be sensibly shortened.

This letter was read during the excited period immediately preceding the Civil War, and no action was taken upon the suggestions it contained; but in 1866 Ammen again presented the subject with such success that the United States Senate directed the Secretary of the Navy to furnish a list of all known data on the subject. A report made in response to this by Rear-Admiral C. H. Davis, Superintendent of the Naval Observatory, stated that, although scanty information had so far been obtained with regard to the Isthmus of Darien, yet of all the series of isthmuses, that of Darien possessed the finest harbors.

This great natural advantage attracted special attention to this locality. Our Government, having obtained permission of the United States of Colombia, in 1869 commenced a systematic survey first of the Isthmus of Darien, after the manner suggested by Ammen; and later this system of exploration was carried to the other isthmuses, all explorations being made by officers of the United States Navy.

In 1872 President Grant appointed a Commission, consisting of three persons—Commodore Daniel Ammen, U.S.N., General A. A. Humphreys, U. S. Corps of Engineers, and Mr. C. P. Patterson, then Superintendent of the Coast Survey—whose province it was to study the results furnished by the United States exploring expeditions; and after the appointment of this Commission, all work by the Naval parties was executed under its direction.

Thus systematized, the surveys continued without interruption for the next 10 years, save for the necessary avoidance of the unhealthy rainy seasons.

No less than 25 different routes have been proposed, and none of these abandoned until careful investigation had shown that either there was some more practicable route in that vicinity, or else that the expenses would have been too overwhelmingly great to have justified the construction of a canal.

The following list shows the principal routes that have been proposed as possible lines for a canal, all of which have been fully investigated; while hundreds of reconnoissances have exhibited the topography on each side of the proposed lines.

Isthmus of Tehuantepec.

From the Bay of Campeche, *via* Tarifa, to the Gulf of Tehuantepec.

Isthmus of Honduras.

From the Bay of Honduras to the Bay of Fonseca.

Isthmus of Nicaragua.

From Greytown, *via* Lakes Nicaragua and Managua, to the Bay of Fonseca;

From the same lakes to Port Realejo ;
From the same lakes to Rio Tamarinda ;
From Greytown, *via* Lake Nicaragua and Sapoa River, to the Bay of Salinas ;
From Greytown, *via* La Virgen Bay, to San Juan del Sur ;
From Greytown, *via* Rio Lajas, to Brito ;
From Greytown, *via* Rio Medio, to Brito ;
From Greytown, *via* Buena Vista Pass ;
From Greytown, *via* the Valley of the Gil Gonzales ;
From Greytown, *via* the Valley of the Ochomoga.

Isthmus of Costa Rica.

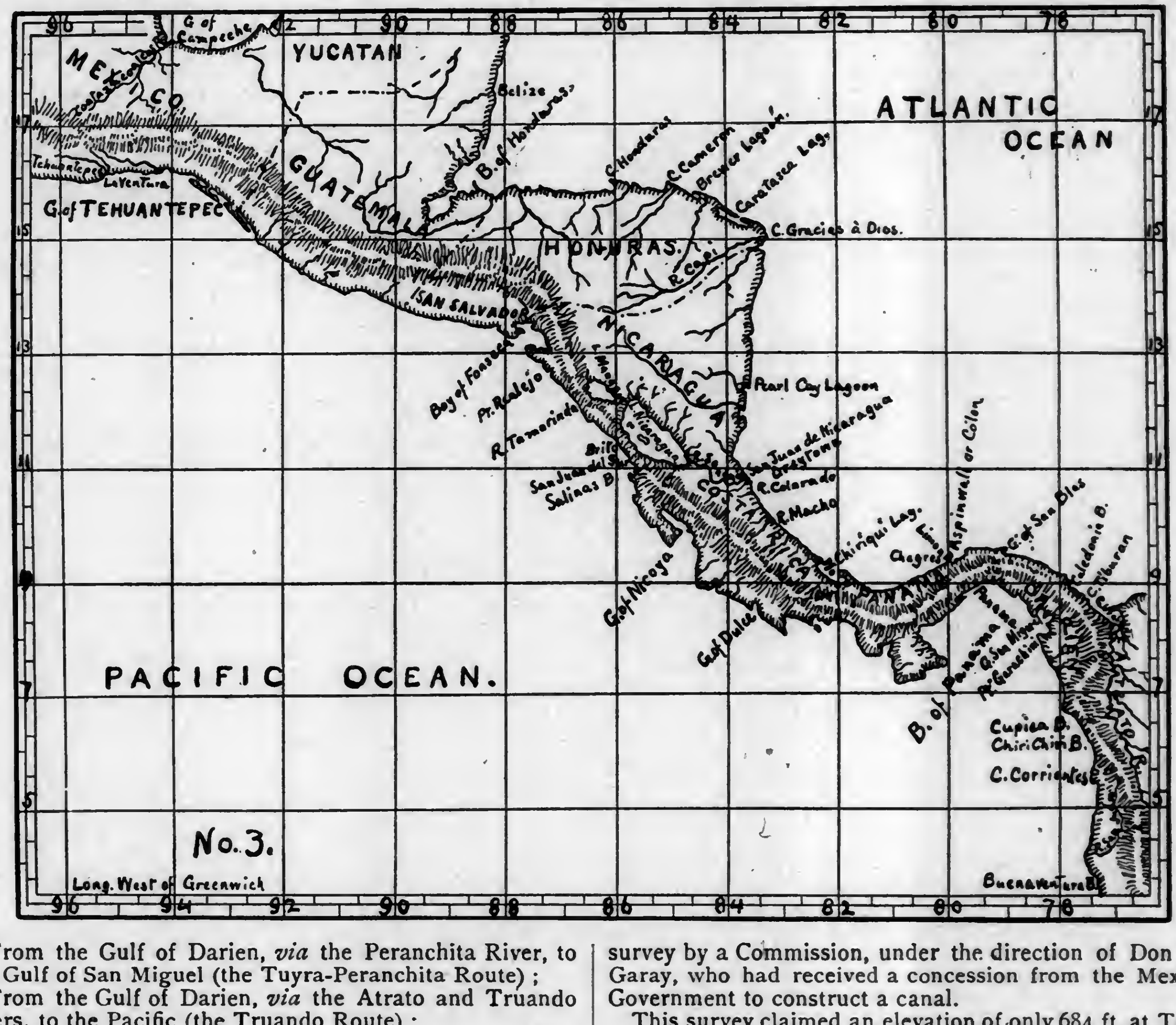
From Chiriqui Lagoon to the Gulf of Dulce.

Isthmus of Panama.

From Aspinwall to Panama ;
From San Blas Bay to the Bayamo River.

Isthmus of Darien.

From Caledonia Bay to the Gulf of San Miguel ;
From the Gulf of Darien (Uraba) to the Gulf of San Miguel (the Tuyra Route) ;



From the Gulf of Darien, *via* the Peranchita River, to the Gulf of San Miguel (the Tuyra-Peranchita Route) ;
From the Gulf of Darien, *via* the Atrato and Truando rivers, to the Pacific (the Truando Route) ;
From the Gulf of Darien, *via* the Atrato and Napipi rivers, to Cupica, or to Chiri Chiri Bay (the Atrato-Napipi Route) ;
From the Gulf of Darien, *via* the Atrato and Bojaya rivers, to the Pacific (the Bojaya Route) ;
From the Atrato River, at its headwaters, *via* the San Juan River, to the Pacific, near Buenaventura Bay.

The surveys may be said to have extended over the entire territory, since it became the province of the surveyors to explore all localities not already definitely known to be impracticable.

The data thus obtained demonstrated succinctly the advantages and disadvantages of each of the principal localities under investigation.

IX.—THE TEHUANTEPEC ROUTE.

There is but a single proposed canal route across this isthmus, extending from the Bay of Campeche, on the Atlantic side, and following the valley of the Coatzacoalcos River, crossing the divide at Tarifa Pass, and thence to the Bay of Salinas Cruz, in the Gulf of Tehuantepec.

During the time of Cortez—1520–34—this territory was explored with a view to interoceanic communication, and traffic was carried on between the two oceans by way of this mountain pass.

Tradition falsified its topography, and it became currently reported that the depression known as Tarifa Pass had an elevation of only a few feet above the level of the sea ; but in 1771 Spanish engineers made a survey between the Bay of Campeche and the Gulf of Tehuantepec, which showed the mountainous nature of the country traversed.

In 1836, Mexico having achieved her independence, a Governmental survey was made ; and also, in 1842–43, a survey by a Commission, under the direction of Don José Garay, who had received a concession from the Mexican Government to construct a canal.

This survey claimed an elevation of only 684 ft. at Tarifa Pass, and proposed a lock canal, to be supplied with water by a feeder canal from the two rivers, Chicapa and Ostuta. The length of the canal proper was to be 50 miles, and that of the feeder, 15 miles. The elevation to the summit was to be attained by 161 locks. The canal, as proposed, must have been of small dimensions, since its estimated cost was only $17,000,000.

The time allowed for the commencement of the work was twice extended, and finally, in 1849, the project became changed into a scheme for the construction of a freight and passenger railway over the same line.

In 1870 Commander (now Rear-Admiral) Shufeldt,

U.S.N., was ordered to make surveys here to determine:

1. The advisability of improving the terminal harbor;
2. To examine the character of the soil and natural obstacles that lay along the proposed line of canal;
3. To find out if there existed in the above-mentioned rivers a sufficient supply of water for a lock canal.

Shufeldt's report showed that the joint delivery of the Ostuta and Chicapa rivers was not sufficient to feed a ship-canal; and, moreover, that it would be impossible to effect a junction between them, as the Ostuta lies 180 ft. below the summit.

He also found that the Coatzacoalcos and Blanco rivers would furnish, at the summit-level, water supply sufficient only for a canal of 22 ft. depth, 60 ft. width at bottom and

162 ft. width at the water surface. The total length of the canal would be 144 miles, crossing an elevation of 754 ft. (reduced by the 22 ft. of canal to 732 ft.) by a system of 140 locks.

To supply water at the summit-level a feeder canal would be necessary, which involved a dam across the headwaters of the Coatzacoalcos River 122 ft. long and 86 ft. high, and another dam across the Blanco River 16 ft. high and 140 ft. in length.

There was necessary, in addition, a feeder canal, 27 miles in length, involving 3 miles of heavy cutting, 3½ miles of tunneling, and finally an aqueduct 1,200 ft. in length.

The Pacific terminus required for the formation of an anchorage the construction of a breakwater 2,000 ft. long; while, although on the Atlantic side there is good anchorage in the Coatzacoalcos River, yet the bar at the mouth of that river showed but 15 ft. in the channel, thus necessitating expensive dredging to form an entrance to the canal.

Shufeldt made no estimate of cost, merely submitting the facts that the surveying parties under his command had found to exist; yet, according to Lieutenant Sullivan's report (page 105), using the same scale of prices that were used in estimating the cost of the Nicaragua Canal, the engineer's estimate here would amount to $130,000,000.

The plan adopted by the Canal Commission appointed by President Grant was to use 100 per cent. instead of the 25 per cent. usually allowed by engineers to cover contingencies. This applied to the above estimates would make the cost amount to $260,000,000.

From the time of Shufeldt's surveys, the idea of cutting through the Isthmus of Tehuantepec has been abandoned, and in its place is now proposed transit across this isthmus by means of a ship railway.

X.—THE HONDURAS ROUTE.

This isthmus, coming next in geographical position, deserves passing mention, because reconnoissances and explorations have been here made, though they have only served to show the utter impracticability of constructing a canal in this locality.

The principal knowledge with regard to its physical characteristics has been obtained from surveys made by the British Honduras Interoceanic Railway Company.

The only route suggested was from the Bay of Honduras to the Bay of Fonseca; and it has excellent harbors in Puerto Caballos, on the Atlantic side, and La Union, on the Pacific.

The length of the line of transit is only 93 miles, but the lowest depression in the dividing ridge has an elevation of 2,956 ft.

XI.—THE ISTHMUS OF NICARAGUA.

The orology of this isthmus differs from the others in that there are here two dividing ridges, between which lie Lakes Nicaragua and Managua.

Lake Nicaragua is a body of water 100 miles in length, 50 miles in width, and having in some places a depth of 150 ft. Its natural water-surface is 107.63 ft. above the level of the oceans. The interior slopes of the mountain ranges discharge their streams into the lake, which has for its outlet the San Juan River, flowing into the Caribbean Sea near Greytown, or San Juan del Norte.

Various routes have been proposed here, all of which contemplate using Lake Nicaragua as a part of the canal line. The route has, from the first, been regarded with favor by those who have given the subject attention. The apparent great length of the line (170 miles) seems at first to place it at a disadvantage, when compared with the shorter lines of transit; but it must be remembered that over 140 miles of this is free navigation, the line of actual canal-cutting being only 28 miles.

One series of routes suggested by Louis Napoleon, afterward Napoleon III. of France, proposed using the San Juan River, Lakes Nicaragua and Managua, and thence a canal to some port on the Pacific.

All other proposed routes have contemplated using the San Juan River, Lake Nicaragua and thence a canal to the Pacific.

Examinations made by Civil Engineer A. G. Menocal, U.S.N., showed the impracticability of using Lake Managua; and surveys made by parties under Commander Lull, U.S.N., and Mr. Menocal, finally reduced the proposed routes to that from Greytown *via* the San Juan River, Lake Nicaragua and the Rio Lajas to Brito.

This route was presented for the consideration of the Paris International Canal Conference in 1879, with an estimated cost of about $65,000,000, but it failed then of acceptance. The route will be discussed at more length in connection with the Panama and Atrato-Napipi routes, these being considered the three most prominent proposed lines.

XII.—THE ISTHMUS OF COSTA RICA.

Three routes have been proposed across this State, as follows:

1. From the mouth of the Colorado River to the Gulf of Nicoya;
2. From the mouth of the Rio Macho to the Gulf of Nicoya;
3. The Chiriqui Route.

The latter is the only route deserving special mention. This extends from Chiriqui Lagoon, on the Atlantic side, to the Gulf of Dulce, both of which are fine harbors, while the line of transit is only 50 miles.

There is, unfortunately, an elevation of 1,600 ft. to be crossed, and this, within five miles of the Pacific Coast, while there is no adequate water-supply for lockage.

XIII.—THE ISTHMUS OF PANAMA.

There have been two routes proposed across this isthmus, as follows:

1. From Aspinwall to Panama;
2. From San Blas Bay to the Bayamo River.

1. The line *from Aspinwall to Panama* has been so thoroughly discussed that its plan and profile are familiar to all interested in the subject.

The isthmus has received numerous instrumental surveys, among which are to be noted that of Lloyd in 1828; that of Garella in 1844; a survey by J. C. Trautwine and another by Colonel George W. Hughes in 1849; one by G. M. Totten in 1857; a survey by Commander E. P. Lull in 1875; also a survey by Lieutenant L. N.-B. Wyse, French Navy, in 1877–78, and finally the detailed surveys made by the De Lesseps Panama Canal Company.

Lloyd's survey crossed a greatest elevation of 633 ft. He demonstrated that the mean tide-level of the oceans was nearly the same.

Garella's survey was made under the authority of Louis Philippe of France.

The surveys of Trautwine and Totten were made in the interest of the Panama Railroad Company.

Totten's observations showed conclusively that there was no difference between the mean levels of the two oceans. There is, however, a great difference between the ranges of the tide at the terminal ports. At Aspinwall the highest tide is only 1.6 ft. above a mean low-water plane of reference, while at Panama the greatest rise of tide is 21.3 ft. This difference in the range is due to the configuration of the coast-line on either side, the outlying chain of Antilles serving to break the tidal influence at Aspinwall, while the Bay of Panama offers no such obstacle.

Investigation shows, however, that although the Atlantic may be sometimes above and sometimes below the Pacific, yet at mid-tide their waters are at the same level.

One feature which has greatly assisted the examination of this locality is the existence of the Panama Railroad. This road was commenced in 1850, the survey being made by Colonel George W. Hughes, U. S. Topographical Engineers.

A previous reconnoissance had discovered a gap with not more than 300 ft. elevation; Colonel Hughes's party found a still lower depression, and located the line from Navy Bay to Panama.

The railroad was constructed in five years, the first blow being struck in January, 1850, and the last rail being laid on the night of January 28, 1855.

The road is, in length, 47 miles, 3,020 ft., and surmounts an elevation of 263 ft. above mean tide of the Atlantic by a cut of 24 ft., the summit ridge being 287 ft. above this plane of reference. Of the entire distance, $23\frac{3}{8}$ miles are level and $28\frac{5}{8}$ miles are straight. There are some very abrupt curves, and the maximum grade is 60 ft. to the mile.

Since the completion of this railroad attention has been called to this portion of Central America as the most convenient point at which to connect the oceans.

XIV.—COMMANDER LULL'S SURVEY.

In 1875 Commander E. P. Lull, U.S.N., by direction of the United States Canal Commissioners, made a close instrumental survey in the vicinity of the Panama Railroad, with a view to the construction of a lock-canal, it being deemed impracticable, from the knowledge of this isthmus, to construct a tide-level canal.

The estimated cost of a lock-canal, as computed from the data furnished by this survey, was $94,511,360. Its dimensions were as follows: Length from sea to sea, 41.7 miles; width at surface, 150 to 160 ft.; width at bottom, 60 to 70 ft.; depth, 26 ft.

The summit-level was placed at $123\frac{3}{4}$ ft., and was to be overcome by the use of 24 locks—12 each side—each with a lift of 10.3 ft.; and in addition a tidal lock at the Pacific terminus was necessary.

The Chagres River, near its junction with the Obispo, changes course abruptly to the northward, which involved the necessity of carrying the canal over this river by a viaduct sufficiently elevated to allow the flood of waters to pass underneath it. This viaduct would be 1,900 ft. long, and elevated 44 ft. above the bed of the Chagres. (*Lieutenant Sullivan's report, page* 118.)

The surface of the water in this viaduct would be the summit-level of the canal. To supply the summit with water, it was proposed to dam the Chagres at a point about 12 miles above the viaduct, raising the waters 36 ft. above the ordinary level; thence the water would be conducted by a feeder canal 10.2 miles long, and passing through seven tunnels aggregrating 13,700 ft. in length, and over two aqueducts into a receiving basin 22 acres in area—this basin to be formed by the construction of a dam, 1,760 ft. in length and 74 ft. high from its lowest foundation, between two spurs of the range of hills forming one side of the valley of the Chagres.

The basin was to be located about 1,000 ft. from the Pacific end of the viaduct. The channel of the Obispo would have to be changed for a short distance in order to give room for the dam.

A channel would have to be excavated in the harbor of Panama for a distance of 9,200 ft., and at Aspinwall for a distance of 1,800 ft. A breakwater would also be required at the latter port in order to protect the entrance to the canal.

The advantages claimed for this route were:

1. An open cut, with but moderate depth of excavation.
2. A comparatively short distance from sea to sea.
3. Fair harbors on either side.
4. Proximity to a well-constructed railroad.
5. Established communication, which exists with the principal ports of the world.

The disadvantages to offset these were:

1. The prevailing calms of Panama Bay.
2. The want of materials for the purposes of construction.
3. The large annual rainfall.
4. The character of the swamp lands in certain portions of the canal-line.
5. The amount of tunneling required for the feeder.
6. A doubt as to the sufficiency of the water-supply at all times.
7. The necessity of introducing a viaduct.
8. The unhealthfulness of the country.
9. The general objections which apply to all lock-canals.

A further discussion of the Panama route will be given in connection with the Nicaragua and Napipi routes.

The *San Blas Route*, as proposed, starts from San Blas Bay, on the Atlantic side, and has its Pacific terminus at the mouth of the Bayamo, or Chepo, River.

This was a favorite route with several explorers, the isthmus being here only 30 miles in width. Surveys were made by Mr. Kelley and by a party under Captain Thomas O. Selfridge, U.S.N.; also a survey by Mr. Wyse.

The profile across this section shows a dividing ridge of over 1,100 ft., while for nearly 10 miles there is a constant elevation of over 300 ft.

Mr. Kelley's scheme comprehended here a sea-level canal, with a tunnel 7 miles in length, piercing this dividing ridge. He proposed to utilize the Bayamo River for 10 miles of its course, thus reducing the actual line of canal to only 20 miles, of which 13 would be open cutting.

The tunnel, as proposed by this scheme, was to have the following dimensions: Length, 7 miles; width at water-surface, 80 ft.; height of tunnel, from bottom of canal to top of arch, 140 ft.; depth of water, 28 ft.

The route, as here proposed by Captain Selfridge, varied slightly from this, and required a tunnel 8 miles in length.

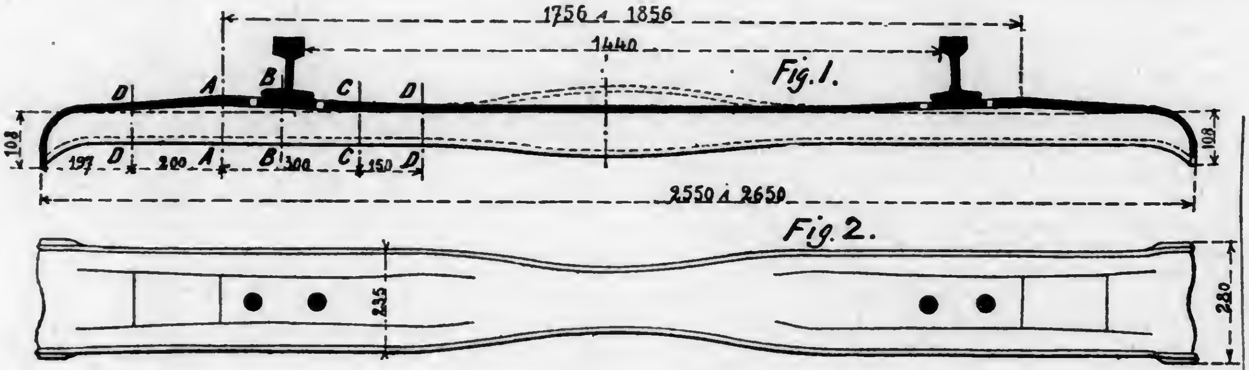
The chief objection to this route was the necessity of tunneling.

The insufficient water-supply precluded the idea of a lock-canal. This was also among the routes presented for the consideration of the Paris International Canal Conference in 1879.

(TO BE CONTINUED.)

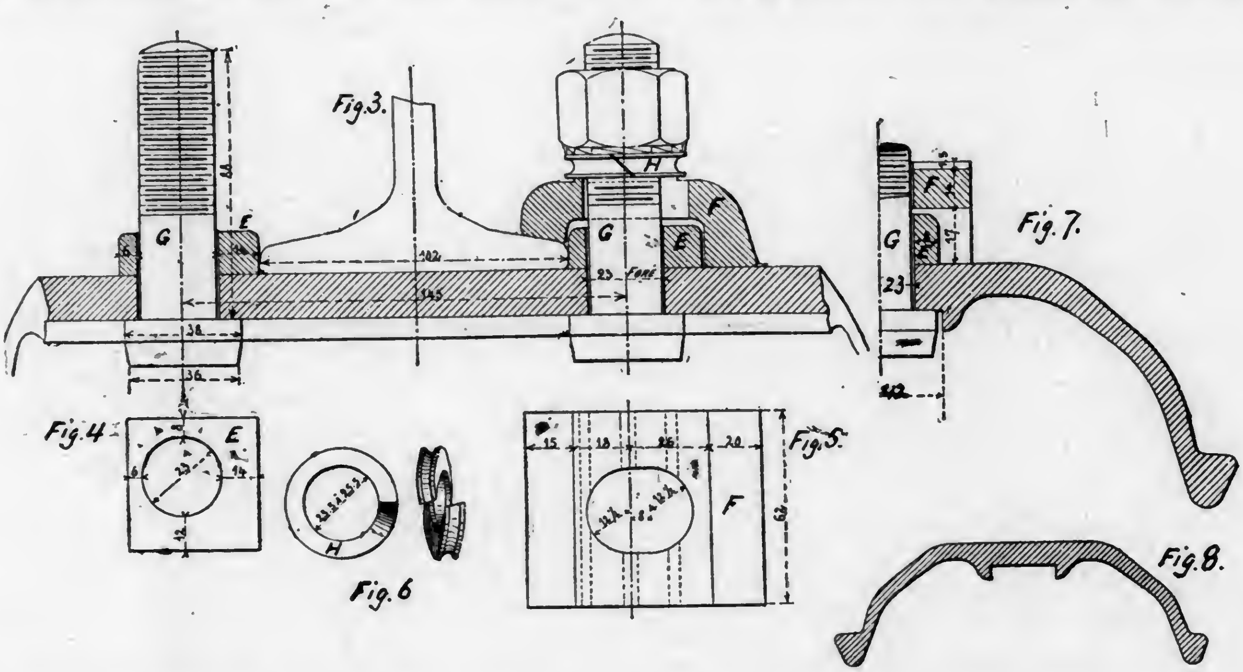
METALLIC TIES IN EUROPE.

IN the debate on the use of metallic ties in the International Railroad Congress in Paris, it was stated by the representative of the Belgian State Railroads that the greatest difficulty experienced on that line was with the cracking or splitting of the ties. These cracks generally commenced at the angles of the square holes made in the tie to receive the chairs which hold the rail in place. It was also stated that the trouble and expense of making these holes was considerable.



In answer to this, M. Kalff, of the Netherlands State Railroads, presented a plan for fastening the rails to the ties, which has been adopted on these lines, and which requires only the drilling of round or oval holes in the metal. These plans, with drawings of the tie used, are shown in the accompanying engravings. In these, fig. 1 is a longitudinal section of the tie, and fig. 2 a view of the tie from below; fig. 3 is a section on a larger scale of a portion of the tie, showing the plan adopted for fastening the rail. This, it will be seen, is done by bolts. The two bolts *G G* have a bearing with their heads in the recess formed on the underside of the tie. These bolts pass through the tie and through square washers or plates, *E E*, which abut against the rail and keep it from moving laterally, and also through clips *F F*, which bear at one end upon the tie and at the other end upon the foot of the rail, holding it down in place. Each of the bolts *G G* has a single nut, which screws down upon a nut-lock *H*. Fig. 4 is a plan of the square plate or washer *E*; fig. 5, a plan of the clip *F*, while fig. 6 shows the nut-lock *H*; fig. 7 is a half section of the tie at *B B*, fig. 1 also showing the fastenings. Fig. 8 is a cross section on the line *A A*, fig. 1; the sections of the tie on the line *C C* and *D D*, fig. 1, are very similar to that shown in fig. 8.

M. Kalff stated that with these fastenings there had been no difficulty in keeping the rails tight and in place; and while there had been some trouble arising from the cracking of the ties, it had not been by any means so great as was experienced on the Belgium roads. Such breakages as had occurred he was inclined to attribute rather to the fact that the ties heretofore used had been somewhat too light in section, or perhaps had not been properly designed. It was not necessary, however, for that reason to abandon the metallic tie, but experiments should be continued until the best section was ascertained by practice.



It was also stated in the discussion that on the Netherlands State Railroads the cost of maintaining the road in good condition with metallic ties was somewhat greater than with wooden ties. The time had been too short, however, to decide this point fully, and their use would be continued for a number of years; that is, until the cost of the renewals begins to have its effects on the expense of maintenance. In this way only can a full and final settlement of the question as to the relative cost of maintenance with iron and wooden ties be reached.

UNITED STATES NAVAL PROGRESS.

THE Naval Appropriation Bill, as reported by the House Committee, authorizes the construction of four new ships of large size. One of them is to be built on the Pacific Coast and one on the Gulf of Mexico or waters tributary thereto, provided contracts can be made at a reasonable cost; but all or any of them may be built in the navy yards, provided no proper bids are received from contractors. One of the four is to be an armored cruiser of about 7,300 tons displacement and 20 knots speed, to cost $2,750,000; the other three are to be sea-going battle-ships of 8,500 tons displacement, to carry guns and armor of the heaviest kind, to have the highest speed, coal endurance and manœuvring powers possible, and to cost $4,000,000 each.

Other appropriations include $30,000 for testing the Ericsson submarine gun; $25,000 for a new proving-ground on the Potomac River; $145,000 for the Washington ordnance shops; and $2,500,000 for the armament of vessels now building.

Such amendments as may be made to the bill in the House will probably change its general character very little; the Senate is an uncertain body, however, and considerable changes may be made there.

The battle-ships proposed by this bill will be the heaviest vessels yet undertaken for the Navy.

THE BARBETTE TURRETED SHIP "PURITAN."

Reference has before been made to the plans adopted for the completion of the *Puritan*, originally begun as a double-turreted ship of the *Monitor* class. These plans were prepared in the Navy Department some time ago. The accompanying illustrations, showing a general view and deck plan of the vessel, with the description given below, are taken from the report of the Bureau of Construction and Repair.

By the new plans adopted for the *Puritan*, the armament and armored protection are greatly increased, and the quarters of officers and crew made far more comfortable and roomy than originally proposed.

No changes are made in the principal dimensions, which are as follows: Length on load line, 291 ft.; breadth, extreme, 60 ft. 1½ in.; mean draft, 18 ft. 2½ in.; displacement, 6,060 tons; tons per inch, 33.64.

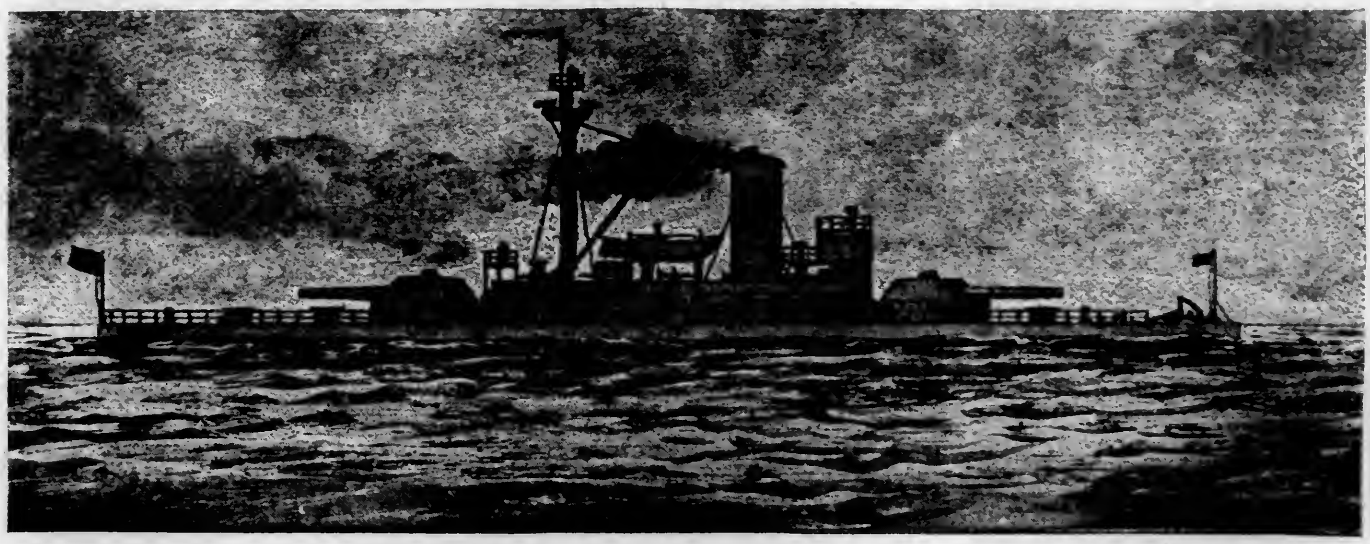
The change consists in substituting for the four 10-in. guns in roller-base turrets, four 12-in. guns in barbette turrets, and instead of the hurricane-deck a superstructure is built between the barbette-turrets.

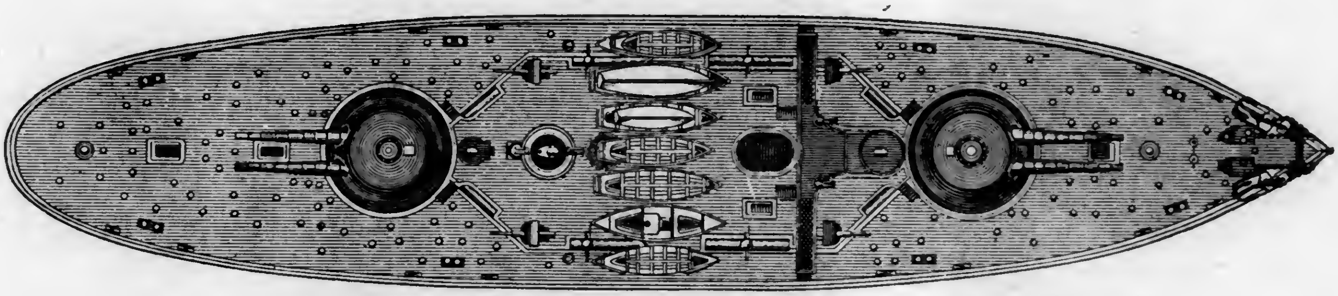
The axes of the 12-in. guns are 10 ft. 6 in. above the water, which will permit their being fought in much heavier weather than was possible with the roller-base turrets. The revolving parts of the turn-tables, the hydraulic machinery for turning them, and the loading and elevating gear of these guns will be protected by fixed barbettes having steel armor 14 in. thick backed by 8 in. of wood, two 20-lb. plates, and a system of horizontal and vertical girders. These guns are inclosed in sloping turn-table shields of steel 8 in. thick. There are six 4-in. rapid-fire rifles, two on the main deck protected by 4-in. armored barbettes built in as part of the superstructure, and four on top of the superstructure protected by shields.

The rest of the battery consists of two 6-pounders, four 3-pounders and four 37-mm. revolving cannon, two of them in the military top.

Two of the 10 boilers now in the *Puritan* have been removed, and forced draft is to be provided for the remaining boilers. With natural draft 3,000 H.P. can be obtained with a corresponding speed of 12 knots, and with forced draft 4,000 H.P., with a speed of 13 knots.

The hull is protected by a belt of armor 5 ft. 7 in. deep, 14 in. thick to a point below the water-line, and thence tapering to 6 in. at the armor shelf for a length of 160 ft., protecting the engines, boilers, magazines, shell-rooms, etc. Immediately forward and abaft these points the belt is reduced to 10 in. in thickness for a length of 20 ft., and at the ends it is reduced to 6 in. This armor is strongly





TURRETED BATTLE-SHIP "PURITAN," UNITED STATES NAVY.

FIG. 4.

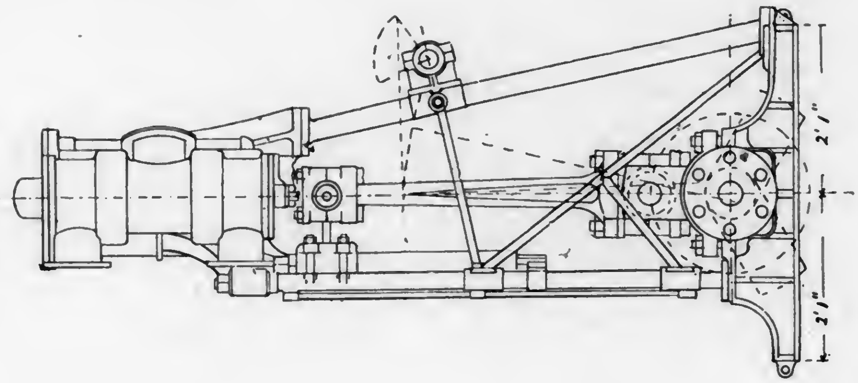


FIG. 1.

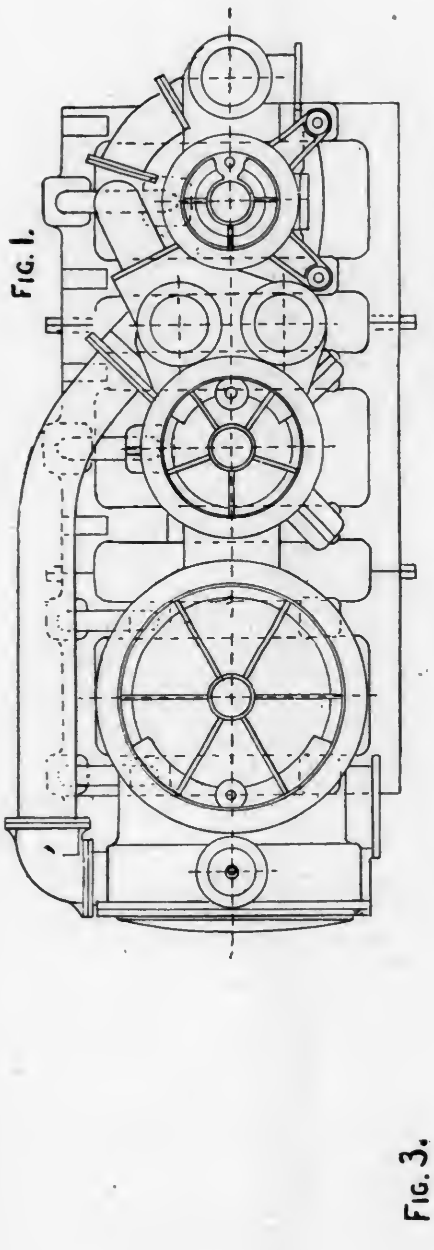


FIG. 2.

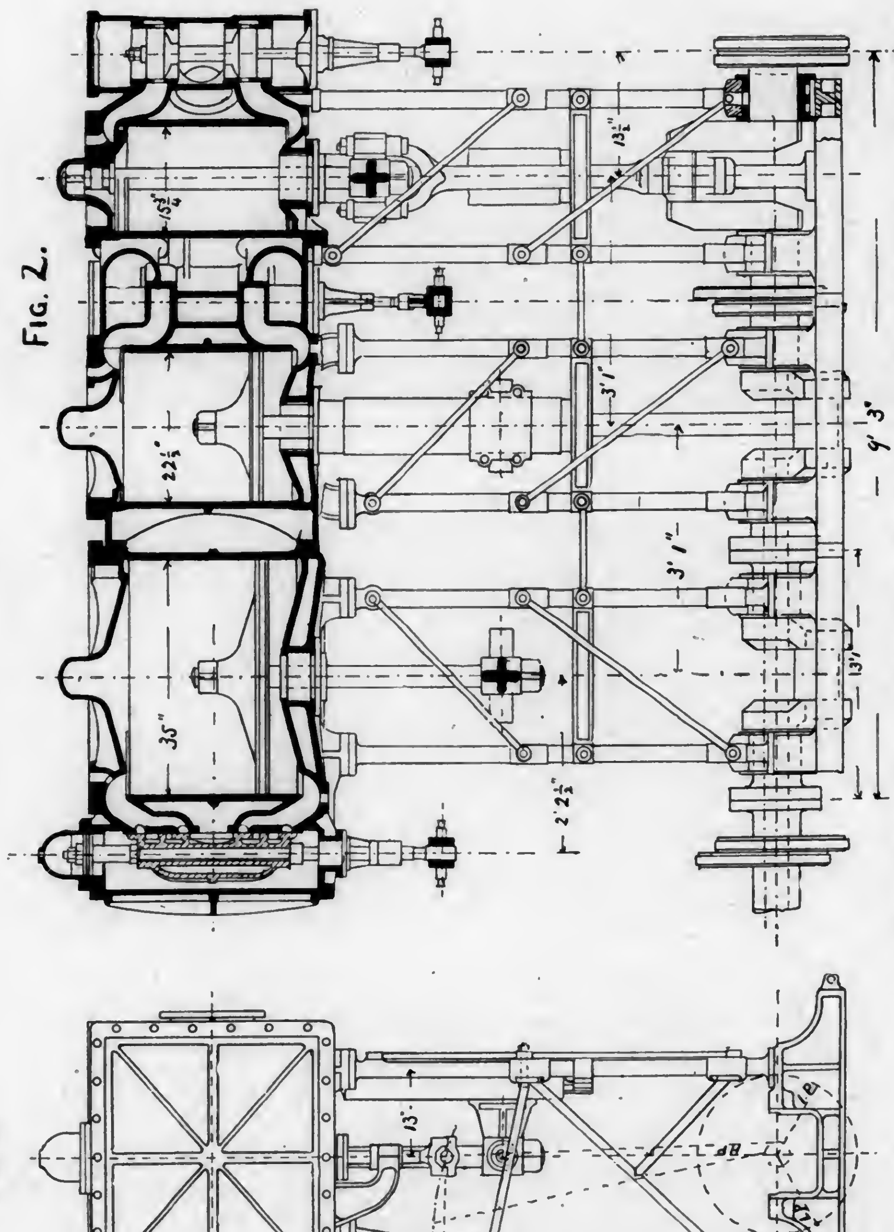
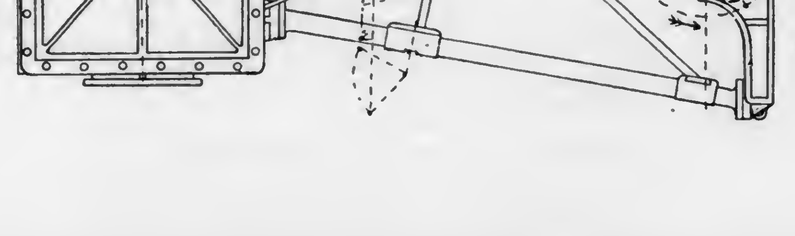


FIG. 3.



TRIPLE-EXPANSION ENGINES FOR GUNBOATS 5 AND 6, UNITED STATES NAVY.

DESIGNED BY THE BUREAU OF STEAM ENGINEERING; GEORGE W. MELVILLE, CHIEF OF BUREAU.

backed by wood lagging and a system of rigid frames and girders. Over the main-deck there are two thicknesses of 1-in. deck armor. There is a conning-tower, protected by 10 in of steel armor, situated immediately abaft the forward barbette. This contains the steering-wheel, mechanical telegraphs, speaking-tubes, etc. For ordinary

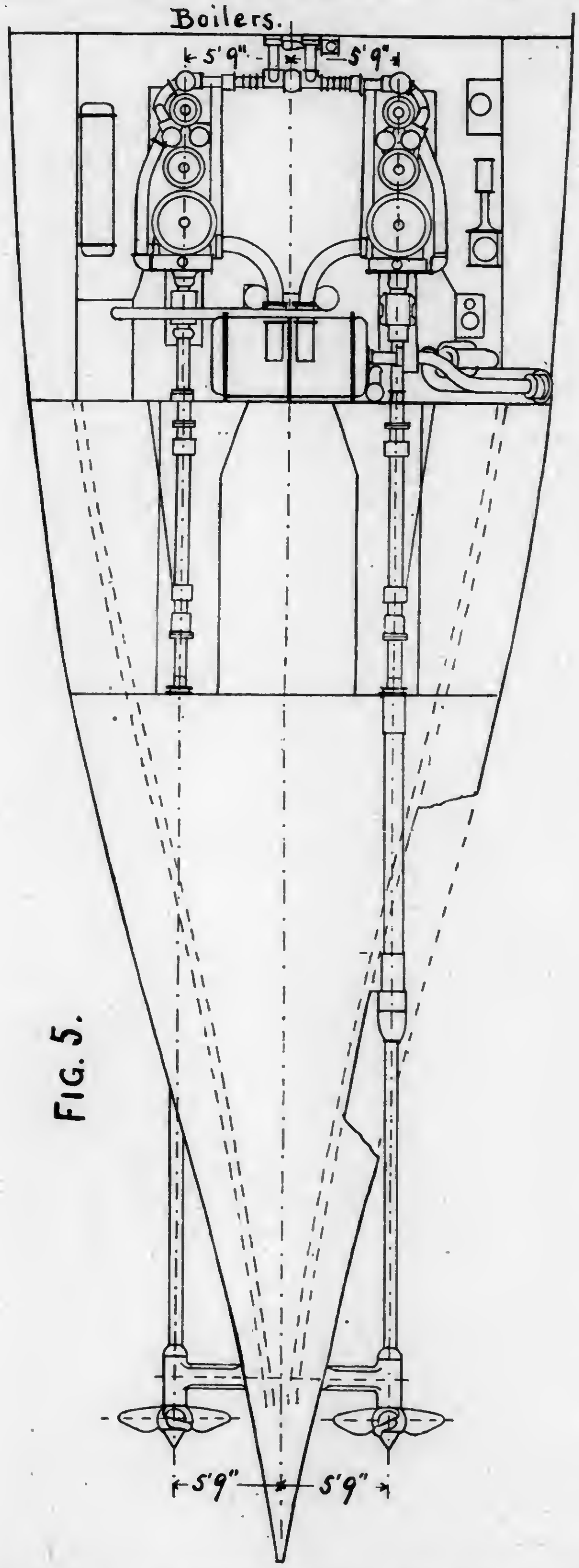


FIG. 5.

use there is a pilot-house of wood fitted with steering-wheel, chart table, speaking-tubes, etc.

The Captain has a cabin in the superstructure between the barbettes, adjoining which are his state-room, bath-room, pantry and office. Forward of this are eight ward-room state-rooms opening into a passage which, just forward of these rooms, widens out into a commodious dining-room, extending from side to side; forward of this again are four more ward-room state-rooms, making 12 in all. Forward of these again are the galley, the officers' water-closets and bath-room and the crew's water-closets and wash-room. These quarters, well lighted and ventilated, will be comfortable in all seasons. On the after berth-deck are the junior officers' quarters, having 10 berths, near which are the pantry, bath-room and lavatory. In the same part of the vessel are the quarters for the warrant officers, having state-rooms for the gunner and carpenter opening into a mess-room, adjoining which is the pantry. Just forward of these is a large compartment which is used as berthing space for the crew. Opening into this space is the Executive Officer's office and Paymaster's office. There is a passage on each side connecting the forward and after berth-decks, and opening into the passage on the starboard side are the armory and navigator's office, and on the port side is the crew's lavatory. Forward there is a large sick-bay, adjoining the dispensary and bath-room for the sick. The remainder of the forward berth-deck is given to the crew, who have on this vessel more room than on most of the modern cruising vessels, giving a most favorable outlook for the health, comfort and contentment of the crew when contrasted with the stifling and crowded quarters of the old monitors.

There are large centrifugal fans for supplying fresh and exhausting foul air, while the system of drainage is such as exists in double-bottom ships of this class. A most complete system of electric lighting is provided not only for internal illumination, but for the side and masthead lights and search-lights. The ship can carry 450 tons of coal at her normal draft.

There is a military mast 20 in. in diameter and 50 ft. above the superstructure deck, placed abaft the smoke-pipe, out of the line of fire for signal purposes, and fitted as an uptake for exhaust ventilation from the engine-room. There are two tops, one for search-lights and the other for revolving cannon. Two steel booms for handling boats are attached to the mast.

The *Puritan* is now at the New York Navy Yard, where the work on her completion is being pushed forward as rapidly as possible.

ENGINES FOR THE 1,000-TON GUN-BOATS.

The accompanying illustrations, taken from the report of the Bureau of Steam Engineering, show the triple-expansion engines designed by the Bureau for the new gun-boats of 1,000 tons displacement, for which contracts have been let. These vessels were described in the March number of the JOURNAL; it may be said briefly that they are 190 ft. long, 32 ft. breadth and 12 ft. mean draft. The description of the engines given below is from the report just referred to.

The new 1,000-ton cruisers or gun-boats will be propelled by twin-screw, vertical, triple-expansion engines, placed in a common water-tight compartment. The two sets of engines are independent except that there is only one condenser for both. An auxiliary condenser with a capacity equal to all the auxiliary machinery, except the main air and circulating pumps, is to be supplied. This will have an independent, combined air and circulating pump. The main condenser will have air-pumps and a circulating pump similar in general features to those for the *Monadnock*.

The valves for the high-pressure and intermediate-pressure cylinders will be plug pistons grooved, one for the high-pressure and two of the same for the intermediate-pressure, while the low-pressure cylinders will have double-ported slide valves, all worked by Stephenson double-bar links.

The boilers will be of the low cylindrical type, all in one water-tight compartment.

Evaporators, distillers, auxiliary machinery, etc., are provided as in the larger ships. Provision is made for heating the feed-water.

The following are the dimensions of the machinery: Cylinders, $15\frac{3}{4}$, $22\frac{1}{2}$ and 35 in. in diameter by 24 in. stroke. The indicated power is 1,600 H.P. at 200 revolutions per minute and 160 lbs. working pressure. Piston-valves for high-pressure and low-pressure cylinders, $7\frac{1}{2}$ in. diameter. Diameter of crank-shaft journals and crank-pins, 7 in.,

with 3½ in. axial holes. Cranks at 120° and sections of shafts interchangeable. The line, thrust and propeller shafts will be about 7 in. diameter, with 3½ in. axial holes.

Cooling surface in main condenser about 2,246 sq. ft. Diameter of air-pumps, 13½ in.; stroke, 12 in. Capacity of circulating pump, 3,000 galls. per minute.

There will be two boilers 9 ft. 9 in. in diameter by about 16 ft. 10 in. long, with three corrugated furnaces of 36 in. diameter in each. Thickness of boiler sheets, ⅝ in. Total grate surface, 100 sq. ft.; total heating surface, 3,360 sq. ft. Forced draft will be by closed fire-room.

In the illustrations given fig. 1 is a plan of one of the engines; fig. 2, a longitudinal section; fig. 3, an end-view looking forward; fig. 4, an end-view looking aft; fig. 5, a plan showing the position of the engines, etc., in the ship; figs. 6, 7 and 8 are cross-sections, showing respectively the position of the twin screws, the boilers and the engines.

The engines for the practice vessel for the Naval Academy are of very similar design and construction in all respects, the main difference being that they are smaller, having

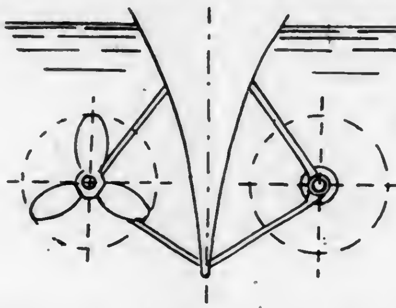


FIG 6.

cylinders 13½ in., 21 in. and 31 in. in diameter and 20 in. stroke. They are expected to develop 1,300 H.P. at 240 revolutions per minute and 160 lbs. working pressure. This ship will have two boilers, each 8 ft. 8 in. in diameter and 17 ft. long, with two corrugated furnaces 39 in. in diameter.

LAUNCH OF THE NEWARK.

The cruiser *Newark*, which was successfully launched at the Cramp Yards in Philadelphia, March 19, was among the first of the large cruisers ordered for the Navy, but her completion has been delayed by different causes. The *Newark* is about the same size and general dimensions as the *Baltimore*, but has been built on different lines, her design being entirely due to the Navy Department.

The principal dimensions of this vessel are as follows: Extreme length, 329 ft.; length on load water-line, 310

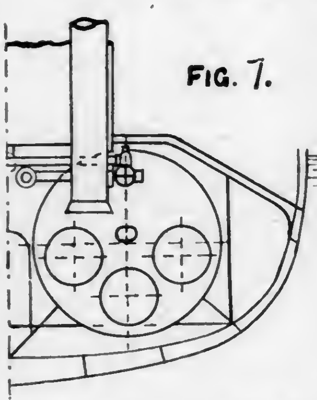


FIG. 7.

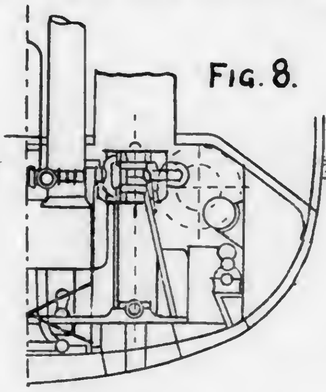


FIG. 8.

ft.; molded breadth, 49 ft.; extreme breadth, 49.14 ft.; depth from flat keel plates to under side of spar-deck, 31.80 ft.; mean draft, 18.825 ft.; displacement to load water-line, 4,083 tons; tons per inch at load water-line, 24.96; area of load water-plane, 10,481 sq. ft.; area of immersed midship section, 807.23 sq. ft. The *Newark* will have three masts, and the area of the sails will be 11,932 sq. ft.

The battery will consist of ten 6-in. rifled cannon mounted on central pivot carriages. None of these guns will be mounted on the forecastle or poop-deck, but will be carried underneath each of these decks. There will also be a heavy secondary battery of rapid-fire and machine guns.

The motive power will be furnished by two triple-expansion engines, one to each screw, having cylinders 34 in., 48 in. and 76 in. in diameter and 40 in. stroke. There are four boilers 13 ft. 6 in. in diameter and 19 ft. 6 in. long, intended to carry a working pressure of 160 lbs. The engines are expected to work up to 6,000 H.P. with natural draft and 8,500 H.P. with forced draft. The maximum speed required is 18 knots per hour, but it is hoped that the ship will do somewhat better.

UNDERGROUND WIRES IN EUROPE.

THE accompanying illustrations, from *l'Electricien* of Paris, show a number of systems adopted in Europe with more or less success for the laying of wires underground. Fig. 1 shows the arrangement adopted in Paris by the Edison Continental Company. The conduits are of concrete 10 cm. (3.94 in.) thick, and the interior dimensions are 37 cm. (14.6 in.) in height and 55 cm. (21.7 in.) in width. At distances of 2 m. (6.56 ft.) apart there are

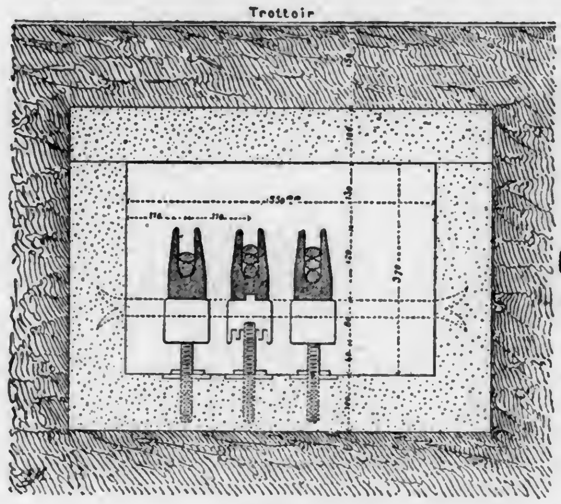


Fig. 1.

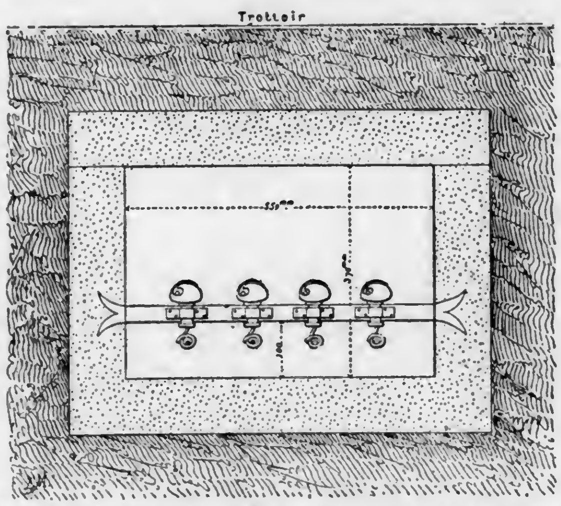


Fig. 2.

placed in the bottom of the conduits bars of iron having each four threaded holes spaced 11 cm. (4.33 in.) apart, and intended to carry the insulators. These are shown in figs. 2, 3 and 4, and are of enameled porcelain having below a hole and screw by which they are fastened upon the iron tires. On the upper side of the insulator proper *P* is a fork *F* of galvanized iron intended to carry the copper cables, and having on each side a small lug, as shown in figs. 3 and 4. These lugs are intended to hold the clamps or yokes which hold the cables in place, as shown in figs. 4 and 5. At a short distance from each insulator is placed a transverse bar of iron screwed in the sides of the conduit, and carrying porcelain insulators with a short curve piece of galvanized-iron wire attached, as shown in figs. 2 and 6. Each one of these can carry two conductors, and

the wires serve to measure the differences in potential at certain points.

The conduits are placed under the sidewalks at a depth of about 15 cm. (5.9 in.). At the street-crossings there are

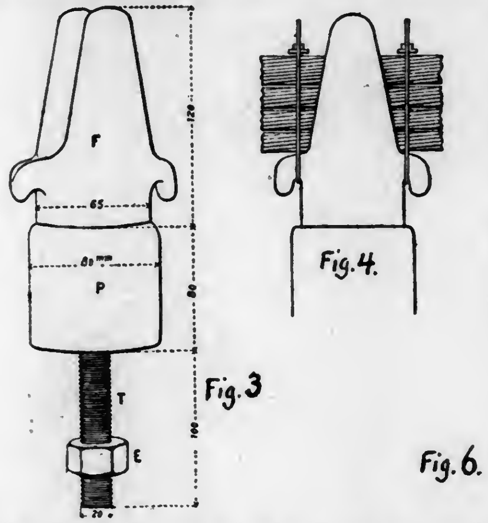


Fig. 3. Fig. 4. Fig. 5. Fig. 6.

placed little wells or pits 6 or 7 m. in depth, which are joined by a cross conduit. In the smaller streets, where

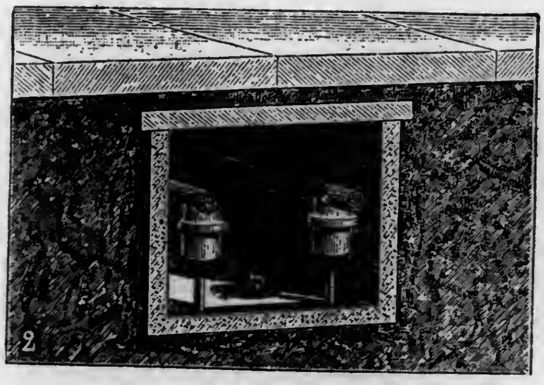


Fig. 7.

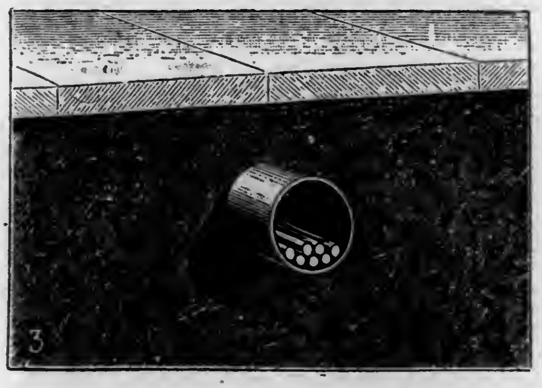


Fig. 8.

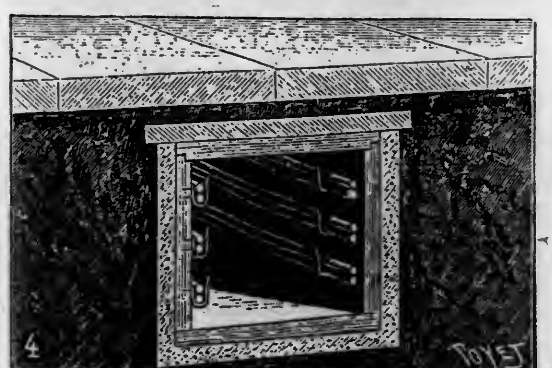


Fig. 9.

the City Government has given the Company only a very contracted space, use has been made of square conduits of pottery, in which the insulators are secured in very much the same way.

The Society for the Transmission of Electric Power has three central installations in Paris, and has used conductors of copper resting upon porcelain carriers, as shown in fig. 7. They are kept in place by means of iron bars held by bolts. The conduits are very similar to those used by the Edison Company.

The Victor Popp Company uses a system entirely different from the other two. Iron pipes 20 cm. (7.97 in.) in diameter, similar to those used for distributing power by compressed air, are placed under the sidewalks with man-holes at intervals. The pipes are joined by bolting flanges with rubber packing. The cables are simply placed in the pipes, as shown in fig. 8. This plan, although very simple, has some inconveniences. The cables are drawn into the pipes by means of the cords left in when they are laid, and, no matter what precautions are taken, they are often damaged. In fact, the disadvantages have been found so great as to neutralize the cheapness in first cost.

For the municipal service at low tension in Paris, conduits of concrete are used in which are fixed wooden frames carrying supports of iron. These wooden frames are about 1.50 m. (4.92 in.) apart. The top piece of the wooden frame is movable, and can be put down rapidly. The cables employed are well covered with rubber. This system is shown in fig. 9. For the high-tension system the same conduits are used, but the cables rest in wooden holders fixed in the conduit.

In Germany the Siemens System, which is shown in figs. 10 and 11, is used almost exclusively. The copper cables are covered with a thick coating of jute saturated with bitumen and rendered flexible by the addition of heavy oil. The cable is then covered by a lead pipe, then by another layer of jute and by two layers of wire rolled or wrapped one over the other in the same direction, the outer one covering the joints of the inner, and finally by a glazing which is intended to preserve the wire. These cables are

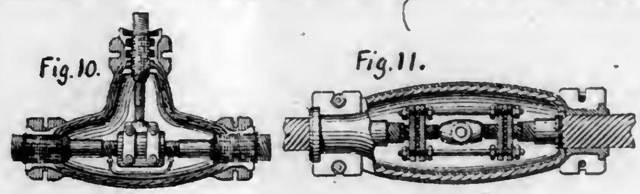


Fig. 10. Fig. 11.

placed directly in the ground, and are joined by junction boxes shown in figs. 10 and 11. The connection having been made, the junction box is filled with melted tar and the opening is then closed by a cover screwed on.

The principal system employed in London is the Crampton plan. In this the conductors used are of a square section, presenting much stiffness, so that the supports can be placed a long distance apart. They are carried by insulators of glass, which are joined to others fixed upon transverse girders by light bars. At intervals man-holes per-

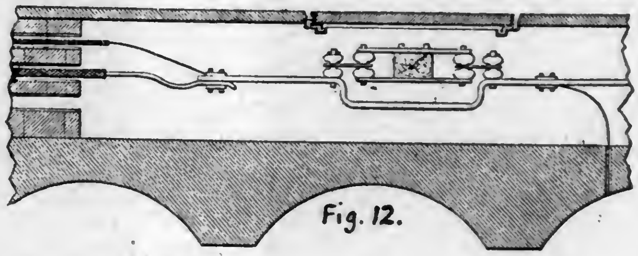


Fig. 12.

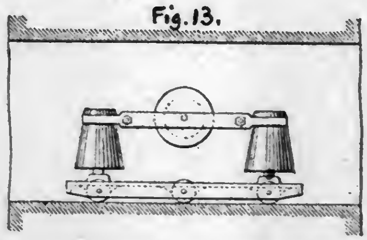


Fig. 13.

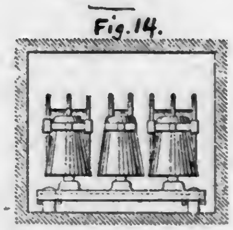
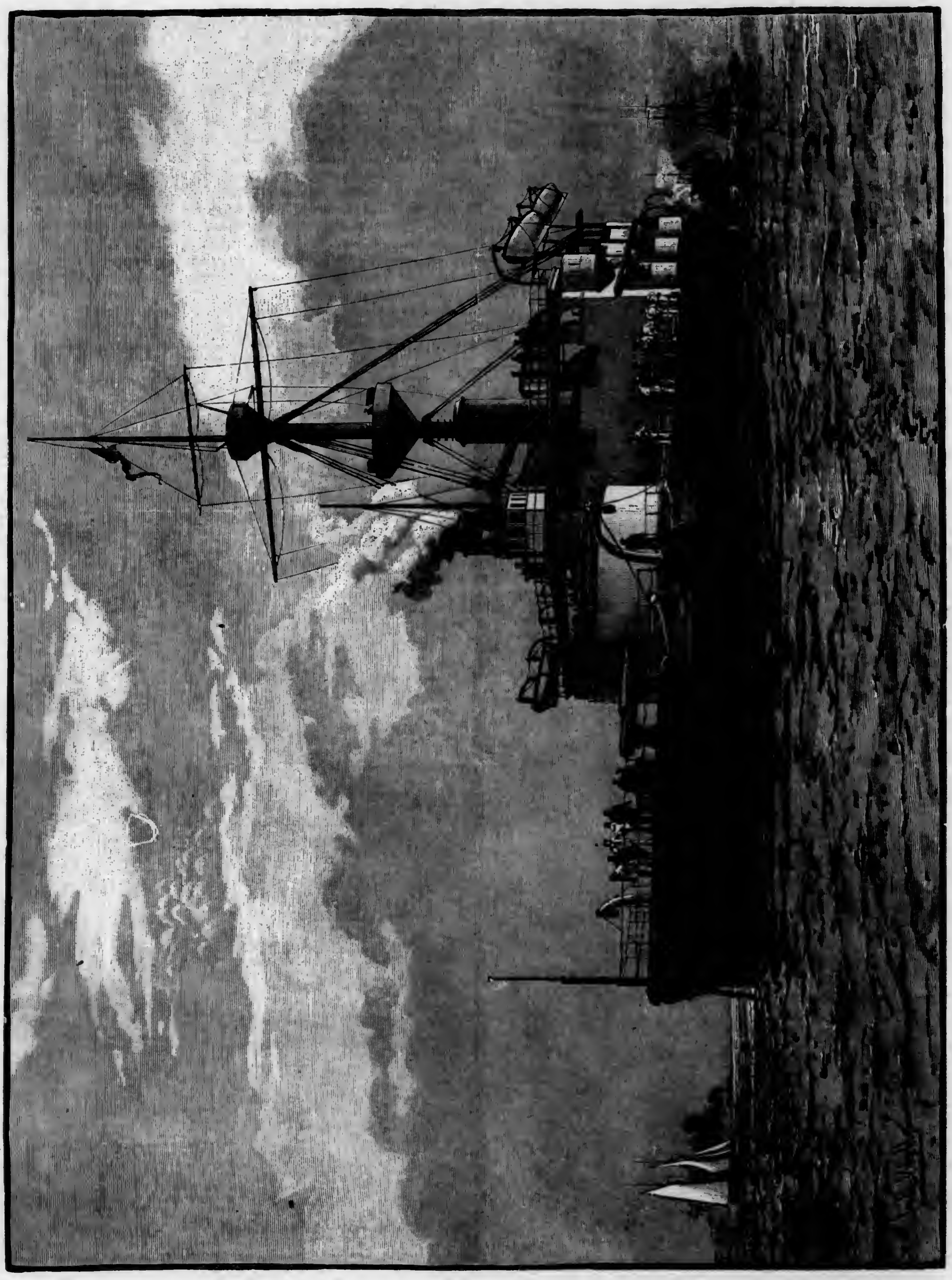


Fig. 14.

mit inspection. The feeders are wrapped in rubber, and are drawn through iron tubes. This arrangement is shown in fig. 12. As it is not always convenient to employ fixed carriers, Mr. Crampton has designed a little car,



BATTLE-SHIP "TRAFALGAR" FOR THE ENGLISH NAVY.

which is shown in figs. 13 and 14, upon which the insulators are placed. Around them is fixed an iron band which carries a pulley, upon which the copper conductor rests. Where this is used the cables can be drawn directly upon their supports from the end of the conduit.

The St. James Electric Light Company uses a copper conductor of rectangular section composed of copper plates joined together in convenient number. The conductors thus formed rest in square slots made in a carrier

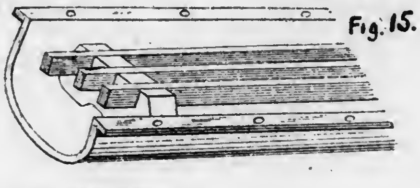


Fig. 15.

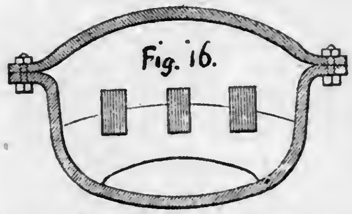


Fig. 16.

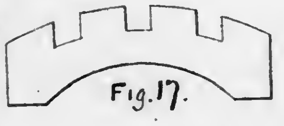


Fig. 17.

of glazed porcelain. These carriers or bridges are placed in a cast-iron conduit of the form shown in figs. 15 and 16, covered by a top which is bolted on. Fig. 17 shows one of the carriers or bridges. The conduit is made in sections about 3 ft. long, which are joined together by flanges and bolts with suitable packing. This makes a very strong and tight arrangement, but has not yet been very extensively introduced.

The House-to-House Company in London uses cables placed in iron pipes. These pipes run into man-holes of the special form shown in fig. 18. The man-hole boxes

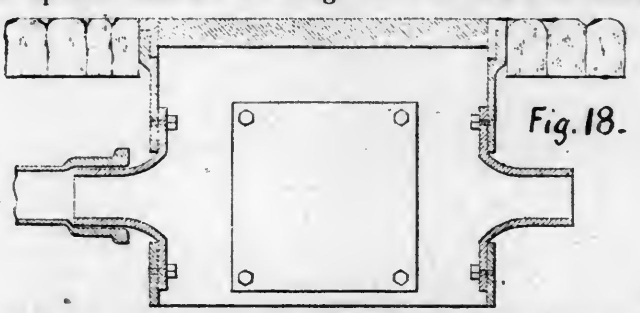


Fig. 18.

are of cast iron, but are open at the bottom, the floors being made simply by sand tamped down well. The cover is movable, and is on a level with the street or sidewalk. This system has been in use about a year, and so far with very good results.

The Calendar Bitumen Company has introduced two different systems. In the first one, which is in use in Liverpool, the cables are placed in cast-iron troughs, in

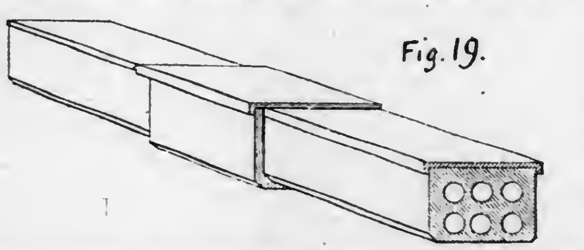


Fig. 19.

which a bituminous composition is poured hot and becomes solid in cooling. This, of course, can only be applied when it is not necessary to move the cables after they are once put in place. In London, the same Company has employed the form of conduit shown in fig. 19. This conduit is made of bitumen pierced with a number of holes as shown, and is in sections about 3 ft. in length. The joints are made by heating the ends of the sections and pressing them together, and then surrounding them with a regular box, which is made tight by pouring hot bitumen into the joints. The advantage claimed for this arrangement is that the cables are preserved from all dampness.

So far as experience has yet shown, preference is given to the system employed in Paris; but it is admitted that further use is necessary to obtain a system which will be thoroughly satisfactory.

THE ENGLISH BATTLE-SHIP "TRAFALGAR."

The accompanying illustration, which is reproduced from the *Illustrated London News*, is a general view of the English battle-ship *Trafalgar*, one of the heaviest and most powerful war-ships afloat. This vessel was launched in 1887, and is now just completed and ready to go into commission. She is built entirely of steel, and in her design great pains was taken to avoid the structural weakness which has been a defect of some other English battle-ships.

The dimensions of the *Trafalgar* are as follows: Length, 345 ft.; breadth, 73 ft.; displacement, 11,940 tons; indicated H.P., 12,000; draft, 27 ft. 6 in. The armor belt at the water-line extends to a length of 230 ft. amidships, and is 20 in. thick at the center, tapering off slightly to the ends, where it encounters and combines with bulkheads of 14-in. armor, thus forming with them a sort of lower citadel, this being decked over with 3-in. steel so far as the ends of the main or upper citadel. The same 20-in. plates that form the walls of this lower portion are continued upward as the walls of the upper citadel, which is 193 ft. in length, but the thickness of the plates is reduced to 16 in. The parabolic ends or bulkheads of the upper citadel are protected with 18-in. armor, as are also the turrets which spring from within its angles. The armor, both of sides and bulkheads, is backed with about 18 in. to 20 in. of teak, and behind this again is a strong inner steel skin 2 in. thick. The plates are compound, having wrought-iron backs with a steel face. Those on the sides taper, or are beveled off beneath the water-line to an edge of only 8 in. The teak is dressed and cut away on the surface so as to fit the plates precisely. The plates at the ends of the main citadel are secured by the bolts being passed through large holes left at intervals in the bed of the turret, otherwise they could not be worked in. Over the whole of the main or upper citadel is a 3-in. steel deck; upon this is built a central-box battery for eight 5-in. breech-loading guns. The side walls of this are of light plates, but the ends are protected from raking fire by 6-in. armor and a backing of teak. Upon the spar deck covering this battery the boats will be stowed and a number of machine guns and quick-firing guns will be mounted, the latter comprising eight 6-pounder Hotchkiss and eleven 3-pounders of the same nature. The ends of the vessel are protected beneath the water-line by a steel deck 3 in. thick, extending from the 14-in. bulkheads before alluded to to the ram at one end and to the sternpost at the other. Thus the vitals of the ship are completely protected by armor-plates from end to end. The number of torpedo tubes will, we understand, be four—one in the bows, one astern and two diagonally from the broadside. The turrets will be revolved by hydraulic power.

Each turret contains two 67-ton breech-loading steel guns, which will be loaded and worked by hydraulic power, being on the disappearing system, hinged upon huge levers, so that they rise for firing within rectangular slots, and descend for the loading position beneath the armored deck.

The dimensions of one of these guns are as follows: Total length, 36 ft. 1 in. (433 in.); length of bore, 405 in.; diameter of bore of gun, 13.5 in.; diameter of powder chamber, 18 in.; length of powder chamber, 66.5 in.; capacity of powder chamber, 17,100 cubic inches; weight of gun, 67 tons; full charge, 520 lbs. prismatic brown powder; estimated muzzle velocity, 1,960 foot-seconds. It is entirely of forged steel, and the disposition of the breech-piece and of the covering hoops have been designed so as to break joints and cover every conceivable spot which might be a source of weakness.

The highest speed attained by this ship is 16½ knots an hour. The coal bunkers can carry 1,200 tons of coal, and with that supply the vessel can steam 6,500 knots. The coal is so carried as to give additional protection to the

engines. The hull is divided by 27 water-tight bulkheads into numerous compartments. The steering gear is placed below the armored deck.

The estimated cost of the ship, ready for service, was about $4,600,000. A sister ship, the *Nile*, is also ready for service.

THE DEVELOPMENT OF ARMOR.

BY FIRST LIEUTENANT JOSEPH M. CALIFF, THIRD U. S. ARTILLERY.

(*Continued from page* 163.)

XI.—IN THE UNITED STATES.

WHEN the necessity for building iron-clad ships of war was forced upon the American people at the outbreak of the rebellion, the development of armor was still in its infancy in Europe, while in the United States, if we except the Stevens Battery, a beginning had not yet been made. France and England had built iron-clad floating batteries, whose value had had ample proof under hostile shot, and in carrying out the policy of creating an iron-protected fleet France already had two sea-going armored fighting ships afloat, while England was pushing toward completion the first of her magnificent array of armor-clads. Neither were the other maritime powers of Europe asleep.

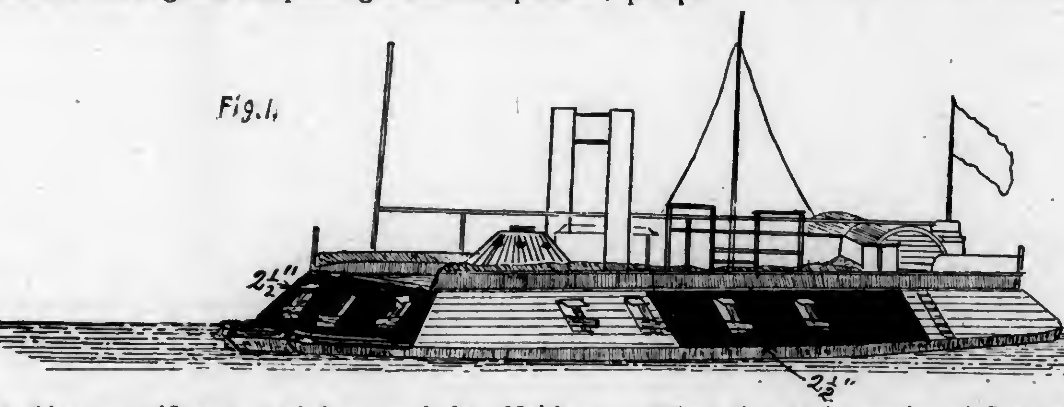
At this time the whole question of armor—of its manufacture, its distribution, its proper thickness was in a transition state. Although the first iron-clads built were of the then existing type of fighting ships, yet the idea of putting guns in a revolving armored turret, upon a vessel of low free-board, was not a new one. Its advantages had been discussed in English naval circles fully a twelvemonth before the *Monitor* was decided upon. As a matter of fact, work on a sea-going armored turret vessel had been begun by the Danish Government before the contract for the building the *Monitor* had been signed.

Whether it was Captain Ericsson, Captain Coles or Mr. Timby who first conceived the idea of a revolving turret for war-ships or batteries, it is certain that to the former belongs the honor of being the first to push to completion a vessel of this description. Not only this, but it appears that as early as 1854 he submitted to the Emperor Napoleon the design for an iron-clad battery with a semi-spherical turret, showing that with him the idea was by no means a new one when he designed the *Monitor*.

No account of the development in the United States of armor-clad ships would be complete without some mention of what was known as the *Stevens Battery*. One cannot to-day read a description of this vessel without the feeling that it was an invention born before its time; for we shall find in any fleet of modern war-ships nearly every device employed by the inventor of the Stevens Battery—independent screws, inclined armor, an all-around fire, a protective deck, and guns manipulated by machinery. In 1842 Mr. Robert L. Stevens, of Hoboken, N. J., was encouraged by the Government to build an iron-plated steamer or battery, to be shell-proof and driven by screws. Work upon it was not actively begun until 1854. Upon his death, two years later, his brother, Edwin A. Stevens, continued the work. The battery was unfinished at the outbreak of the rebellion, and the offer of its owner to push it to completion and turn it over to the Government, to be paid for only after it had proved successful, was not accepted. Mr. Stevens continued work upon it, and at his death, in 1868, willed it to the State of New Jersey, together with a large sum of money for its completion. This proving insufficient, it was offered for sale in 1874. A bid was received from the Navy Department and accepted, contingent upon an appropriation by Congress to pay for the vessel. Failing to secure the necessary appropriation, the battery was broken up and sold for old iron.

The battery had a length of 420 ft. by 52 ft. beam; a continuous water-line belt of armor made up of solid slabs of iron $3\frac{1}{2}$ in. in thickness; a 180-ft. central casemate, covering the machinery, whose sides and ends had a slope of 60° with the perpendicular, and were covered with $6\frac{3}{4}$-in. armor-plate. Before and abaft the casemate was a protective deck below the water-line, provided with $1\frac{1}{2}$-in. plating. The motive power was provided for by four powerful compact engines to each of two independent screw-propellers. The loading and training of the guns was to be done by machinery, and the guns, instead of being within the casemate, were in barbette on top of it. Provision was made for partially submerging the battery for action by the admission of water into compartments, which could be quickly emptied again by powerful steam pumps.

Fig. 1.



When the special session of Congress convened on July 4th, 1861, to provide means for suppressing the rebellion, Secretary of the Navy Welles, in a message, called attention to the question of iron-clad steamers or floating batteries, but with no very hearty recommendations on the subject beyond the suggestion that a board of officers be appointed to inquire into and report upon the matter. A month later Congress authorized the Secretary of the Navy to appoint such a board to investigate the whole subject, examine plans and make recommendations, and appropriated a million and a half to carry out such recommendations as the board might make.

The board did not take a sanguine view either of the practicability or desirability of attempting to build iron-clad ships. The prejudice in favor of wooden ships and of old methods was strong, but after wrestling with the subject six weeks, at the end of that time, as a compromise, the board recommended, that from the many plans submitted, three armored vessels should be built—the *Monitor*, the *Galena* and the *New Ironsides*, as representing the three most promising types. The board, after stating the objections to iron-clad ships and the claims put forth in their behalf, took occasion to say: "We, however, do not hesitate to express the opinion, notwithstanding all we have heard or seen written on the subject, that no ship or floating battery, however heavily she may be plated, can cope successfully with a properly constructed fortification of masonry," and adds, "It is assumed that $4\frac{1}{2}$-in. plates are the heaviest armor a sea-going vessel can safely carry."

Across the Potomac the Confederate authorities were more alive to the value of iron-protected vessels than they seemed to be at Washington. As early as May 8, 1861, Secretary of Navy Mallory urged the construction of iron-clad vessels, and a few weeks later work on the *Merrimac*, their first iron-clad, was begun.

It is generally supposed that the *Monitor*, the contract for whose construction was signed on October 4, was the first Federal iron-clad to take the field, or rather the sea, and that her fight in Hampton Roads was the first actual test of armor on this side of the Atlantic; but neither supposition is correct. While the Naval Board was as yet uncreated, the Quartermaster-General of the Army, in July, 1861, advertised for proposals to construct seven iron-clad gun-boats for service on the Western rivers, and on August 7, Mr. Eads, of St. Louis, signed a contract to construct these seven vessels, ready for their ammunition and armament, within 65 days. Work was begun soon after and pushed day and night, and Sundays as well. On October 12, in 45 days from the laying of her keel, the *St. Louis*, the first United States iron-clad, was launched, with engines on board, and this before the keel of the *Monitor* had been laid down; and these vessels received their baptism of fire some weeks before the latter vessel was turned over to the Government.

Owing to some changes in the design, and delayed payments on the part of the Government, these vessels, together with an eighth afterward contracted for, were not entirely finished until January 15, and were put in commission the next day. In the contract signed by the Quartermaster-General neither the thickness of the armor-plate nor the method of applying it was specified. This document says: "It is intended to protect the boilers and engines of these vessels with iron plates of sufficient thickness and placed in a suitable position to protect them from injury from the effect of shot and shell, for which purpose 75 tons of iron plating have been estimated."

These vessels were a little over 500 tons burden, flat-bottomed, 50 × 170 ft., and propelled by a single enclosed paddle-wheel a little forward of the stern. A casemate, in the shape of a square box, with sides and ends sloping at an angle of 45°, extending from the curve of the bow to that of the stern, contained the paddle-wheel, machinery and a battery of 13 guns. As they came from the hands of the builder we find the 75 tons of armor-plate disposed in the form of iron slabs 2½ in. thick and 11 in. in width, rabbeted together. With the supposition that they would only fight bows on, the forward ends of the casemate received a complete covering of armor upon a backing of 24 in. of oak. A short space abreast the engines and boilers was plated with armor on a 4-in. backing, leaving the remainder of the sides and the stern wholly unprotected. The pilot-house was at the forward end of the casemate, and plated with 2½-in. armor. Such were the first armor-clads built in the United States. In later constructions the armor was increased to 3 in. on the ends and 2½ in. on the sides, with an increased thickness of backing. The distribution of the armor upon these boats is shown in fig. 1.

While the Quartermaster-General of the Army was building a fleet of iron-clads for operations on the Western rivers, the naval authorities were not idle. As has been said, the Naval Board recommended the construction of three vessels of totally different types for service on the Atlantic coast. Of these but one was ever duplicated—the *Monitor*. Its timely appearance and the happy outcome of its conflict with the *Merrimac* made it at once a favorite, and it became the prototype of every iron-clad vessel built during the war upon the Atlantic seaboard, with two or three exceptions, and its name came to be used as a designation for a whole class of vessels whose central idea was, as has been said, that of a fort upon a raft.

The keel of the *Monitor* was laid in October, 1861, and the completed vessel was finished and turned over to the Government in the latter part of the following February. The general features of the *Monitor* are too well known to need detailed description. As to her armor, its distribution is shown in fig. 2.

The side armor was made up of five 1-in. wrought-iron plates, tapering to the bottom of the belt to 3 in., with a backing of 23 in. of oak. The deck was protected by two ½-in. plates of iron over 6 in. of oak planking. The side armor was blunt-bolted to the backing, the bolts coming a little short of the inner surface. The turret armor was made up of eight 1-in. plates without backing, and the turret was revolved by machinery about a central spindle. The two gun-ports were closed with iron pendulum shutters. The pilot-house was near the bow, and consisted of square iron logs 9 in. in thickness, notched at the ends and bolted together at the corners. A narrow space between the first and second layer of logs gave an all-around horizontal field of view. The turret-plates were held together by through bolts set up with nuts on the inside.

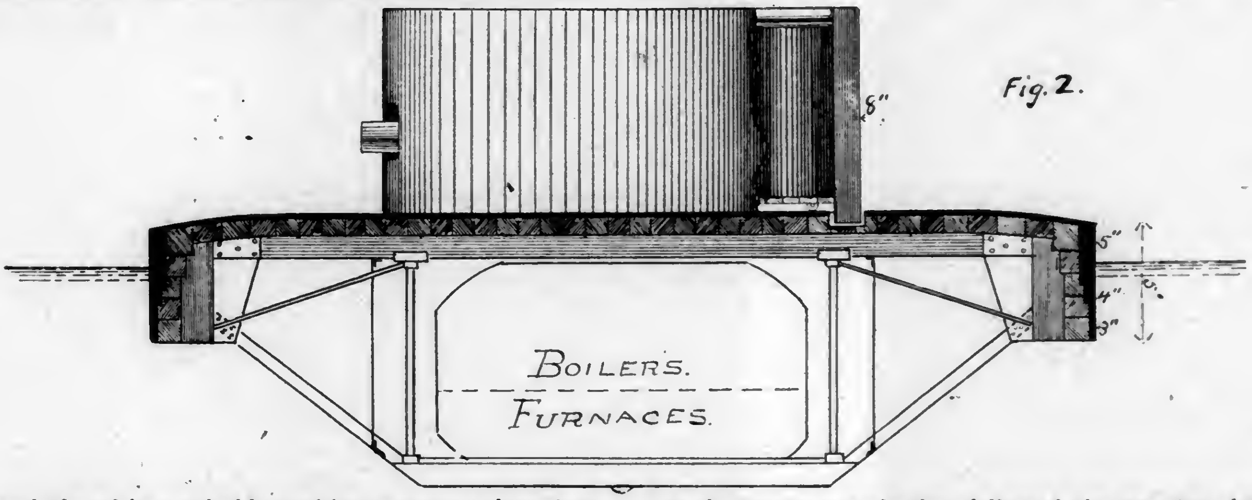


Fig. 2.

In the turret vessels that followed the *Monitor*, known as the *Passaic* class, the thickness of turret armor was increased to 11 in., and a cylindrical pilot-house was placed above the turret, composed of 8 in. of iron in 1-in. plates. The side armor was the same—5 in.—but the wood backing was increased to 39 in. In the *Puritan* and *Dictator*—sea-going turreted iron-clads—the side armor was increased to 6 in. and the backing to 42 in. The armor on the turret was increased to 15 in. in two drums, each made up of 1-in. plates, with segments of wrought-iron hoops, 5 in. in thickness, between the drums. In the *Kalamazoo* class of double-turreted monitors, the most powerful of any of the vessels constructed or planned during the war, the side armor was made up of two layers of 3-in. plates, backed by 30 in. of oak, strengthened at the water-line by iron stringers let into the backing a few inches apart. The turrets had a thickness of 15 in. of iron, without backing. In all the vessels of the monitor type, except the side armor of last-mentioned class, the armor was made up of 1-in. plates. The turret armor of all was of this description. The use of bolts and nuts in setting up the turret plates was a grave mistake, as a very large percentage of the casualties in the monitor turrets was due to flying nuts and fragments of bolts.

By far the most successful iron-clad of the Federal war-fleet was the *New Ironsides*, one of the original three ordered by the Naval Board. She was a casemated sea-going armor clad, with the sides of the casemate inclined at an angle of 30° from the perpendicular, and protected by 4½ in. of *solid* armor-plates, with a backing of 21 in. of oak. The water-line belt was carried completely around, but otherwise the ends were without armor. The armor

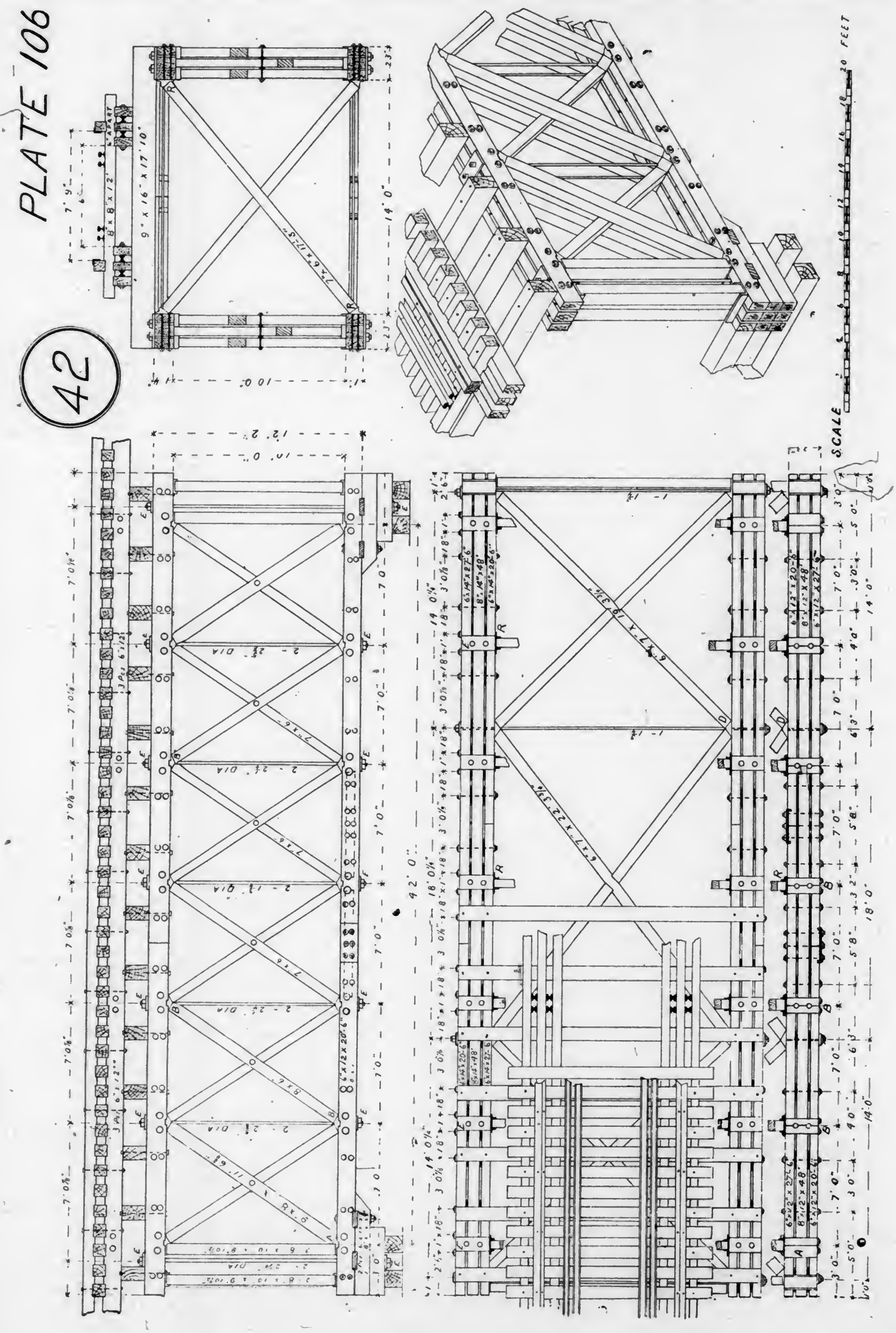


PLATE 106
42
SCALE
20 FEET

was secured to the backing by wood screws reaching two-thirds through the wood.

The superiority of the 4½-in solid armor of the *New Ironsides* over the laminated plates of the monitors was most decided. Not only this, the armor fastenings were in every way superior. The wood screws of the one held firmly where the blunt bolts of the other would be shaken loose and lose their grip ; while, as a protection against the flying nuts and bolt-heads of the monitor pilot-houses and turrets, all sorts of expedients had to be resorted to.

As has been stated, the first iron-clads built in the West were constructed under the auspices of the War Department, with a naval officer in active supervision. When finished naval officers were assigned to command, and their crews were made up largely of navy enlisted men, supplemented by details from the army. The vessels themselves were, however, under the general control of the army commander. This division of authority naturally led to complications, and after about a year's trial this anomalous state of affairs was ended by a transfer of the whole matter of construction and control to the Navy Department, where it properly belonged.

Although the casemated type of armor-clads was generally adopted in the West, there were, however, a number of light-draft turret vessels constructed ; three with single turrets of 6½-in. and four with double turrets of 8½-in. armor. In addition to these, there was a class of armored vessels known as "tin-clads." These were stern-wheelers, all of them, drawing not over 3 ft. of water, and covered all around to the height of 11 ft. with iron plating from ½ in. to ⅝ in. in thickness, and capable of resisting musketry. The boilers were protected to resist projectiles from field guns. Armed with howitzers or light-rifled guns, these boats did gallant service among the bayous and narrow streams where other craft could not venture.

The iron-clad fleet of the United States built and begun from 1861 to 1865 consisted of 82 vessels, not including the "tin-clads." Of these, 64 were turret and 18 casemate vessels. A number of these were never completed, and some were found, when finished, to have no practical value.

(TO BE CONTINUED.)

THE USE OF WOOD IN RAILROAD STRUCTURES.

By CHARLES DAVIS JAMESON, C.E.

(*Continued from page* 158.)

CHAPTER XXIV.

HOWE TRUSS DECK BRIDGES.

THE accompanying plates show a design for a Howe truss deck bridge. The drawings are made in the same way as those for the bridges given in previous numbers, but on a somewhat larger scale, which will, it is believed, make them easier to read.

The design is for a bridge of 42 ft. span, Plate 106 showing the general design and Plates 107 and 108 the details and castings.

No. 44. BILL OF MATERIAL FOR HOWE TRUSS DECK BRIDGE, 42 FT. SPAN. PLATES 106, 107 AND 108.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2¼ in.	14 ft. 6 in.	68	Int'nal bolts	¾ in.	2 ft. 1½ in.
8	"	2⅝ in.	12 ft. 10 in.	12	Bolster-b'lts	1¼ in.	2 ft. 4 in
8	"	2¼ in.	12 ft. 10 in.	56	Floor-bolts.	1¼ in.	3 ft. 0 in.
4	"	1¾ in.	12 ft. 10 in.	28	Tr. str'r b'ts	¾ in.	2 ft 10 in.
8	Laterals.	1¾ in.	18 ft. 6 in.	24	Tie-bolts.	¾ in.	2 ft. 6 in.
16	String'rb'lts	¾ in.	2 ft. 6 in.	14	Guard-bolts.	¾ in.	1 ft. 3 in.
92	Chord-bolts.	¾ in.	2 ft. 0½ in.	24	Spikes.	½ in.	....
12	Brace-bolts.	¾ in.	2 ft. 0½ in.				

Timber.

No. of Pieces.	Description.	Size.	Length.
4	Top Chord.........	6 in. × 14 in.	27 ft. 6 in.
4	" "	6 in. × 14 in.	20 ft. 6 in.
2	" "	8 in. × 14 in.	48 ft. 0 in.
4	Bottom Chord......	6 in. × 12 in.	20 ft. 6 in.
4	" "	6 in. × 12 in.	27 ft. 6 in.
2	" "	8 in. × 12 in.	48 ft. 0 in.
8	Main Braces........	9 in. × 8 in.	11 ft. 6⅝ in.
8	" "	8 in. × 6 in.	11 ft. 6⅝ in.
8	" "	7 in. × 6 in.	11 ft. 6⅝ in.
12	Counters....	7 in. × 6 in.	11 ft. 6⅝ in.
16	End Posts..........	8 in. × 10 in.	9 ft. 10½ in.
8	Laterals......... ..	6 in. × 7 in.	19 ft. 3¾ in.
4	"	6 in. × 7 in.	22 ft. 3¾ in.
4	"	6 in. × 7 in.	19 ft. 3¾ in.
4	"	6 in. × 7 in.	13 ft. 10½ in.
14	Internal...........	7 in. × 6 in.	17 ft. 3 in.
8	Bolsters............	6 in. × 10 in.	6 ft. 0 in.
8	"	8 in. × 10 in.	6 ft. 0 in.
8	Bridge-seat..	6 in. × 10 in.	4 ft. 0 in.
4	" "	8 in. × 10 in.	4 ft. 0 in.
4	Sills................	12 in. × 12 in.	18 ft. 0 in.
14	Floor-beams........	9 in. × 16 in.	17 ft. 10 in.
6	Stringers............	6 in. × 12 in.	48 ft. 0 in.
44	Ties.....	8 in. × 8 in.	12 ft. 0 in.
2	Guard-rails.........	6 in. × 6 in.	48 ft. 0 in.
4	Plank..............	2 in. × 8 in.	48 ft. 0 in.
8	Blocks....	2 in. × 8 in.	2 ft. 0 in.

Castings.

Number : 8 of pattern *A* ; 20 of *B* ; 8 of *C* ; 8 of *D* ; 28 of *E* ; 56 of *F* ; 60 of *G* ; 32 of *H2* ; 16 of *J4* ; 120 of *J2* ; 600 of *J1* ; 2 of *K* ; 4 of *L* ; 4 of *M* ; 2 of *P* ; 28 of *R* ; 8 of *S*.

With the accompanying bill of material this design will require little or no further explanation ; but some remarks upon it will be made in a future chapter.

(TO BE CONTINUED.)

COAL-FIELDS OF THE STATE OF WASHINGTON.

(Paper read before the Tacoma Society of Civil Engineers, by W. J. Wood, C.E).

THE coal-fields of the State of Washington, or, I might say more correctly, the coal measures of the Puget Sound basin, consist of alternating beds of sandstones and shales, interstratified with many beds of carbonaceous shales and coal, showing that the period or age is of tertiary formation.

It is found that they lie in a wide trough between the Cascade and Olympic ranges, and east of the Cascade Mountains are found also extensive coal basins of older formations. The lignites of this country, however, are found in the central part of the trough lying west of the Cascade Mountains and north of Green River, and stratigraphically in the upper series, while south of the above-mentioned places and lower down in the measures will be found the true coals, or those resembling them. It is the prevailing theory that the tertiary rocks rest unconformably on the cretaceous—that is to say, that they were separated from each other by a lapse of time, during which the folding of the older coals and elevation of the mountains took place, and that probably after the development of the latter formations there was a general submergence, depositing the tertiary strata, which follows the cretaceous, and I have found in my examinations hints of the latter formations in various positions. But it is not improbable that in some places there may be a more or less complete strata of passage beds between the cretaceous and tertiary, as we find by comparison on the eastern slope of the Rocky Mountains, where I observed hints of it three years ago in Colorado, Wyoming and Montana coal-fields. I might add that it is quite possible that there may be two unconformable series of tertiary rocks. However, much

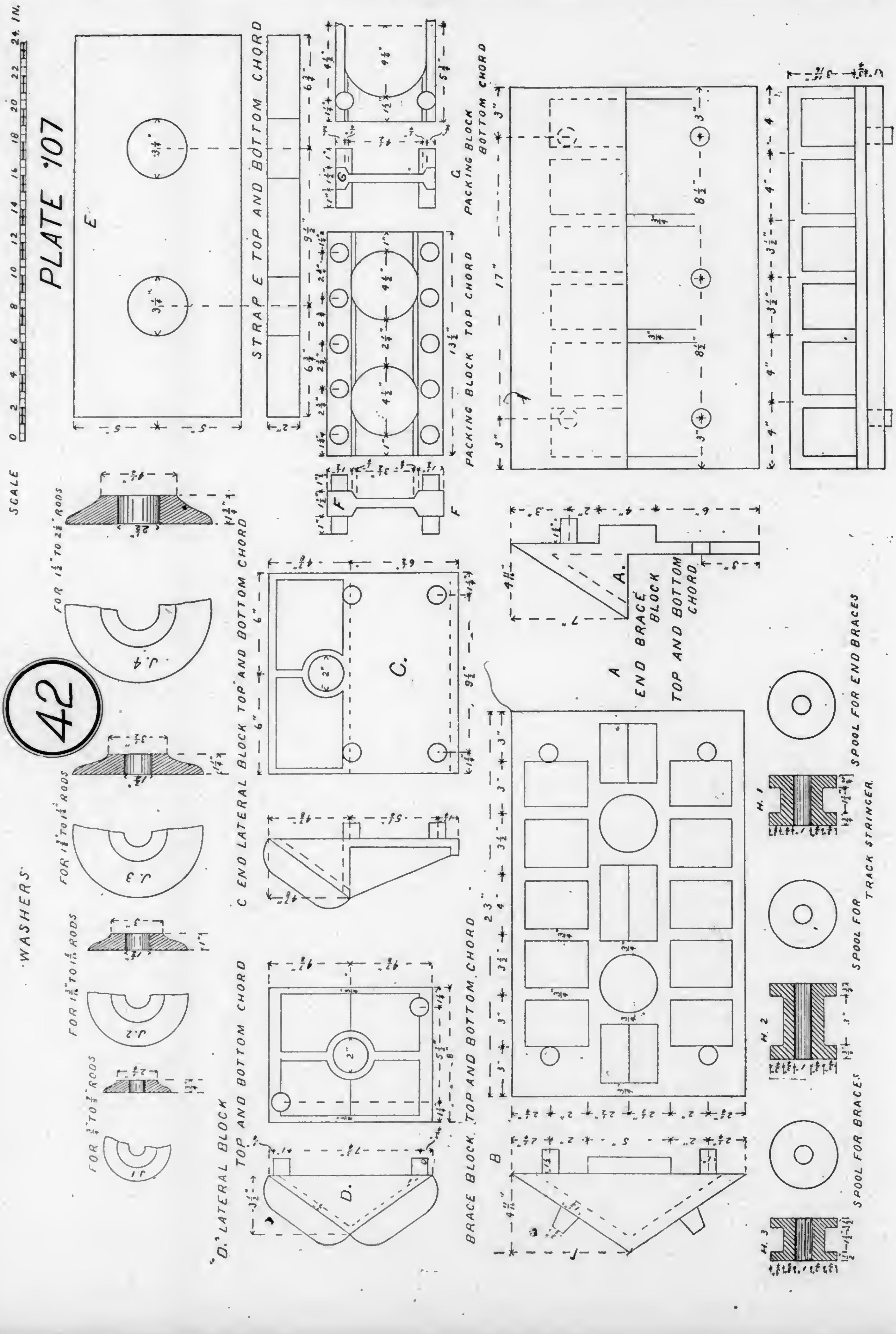


PLATE 107
SCALE
0 2 4 6 8 10 12 14 16 18 20 22 24 IN.
E
STRAP E TOP AND BOTTOM CHORD
PACKING BLOCK TOP CHORD
G
PACKING BLOCK BOTTOM CHORD
F
A END BRACE BLOCK TOP AND BOTTOM CHORD
A.
C END LATERAL BLOCK TOP AND BOTTOM CHORD
C.
BRACE BLOCK TOP AND BOTTOM CHORD
B
"D." LATERAL BLOCK TOP AND BOTTOM CHORD
D.
WASHERS
FOR 1½" TO 2⅛" RODS
J.4
FOR 1⅛" TO 1½" RODS
J.3
FOR 1⅛" TO 1⅜" RODS
J.2
FOR ¾" TO ⅞" RODS
J.1
42
SPOOL FOR END BRACES
H. 1
SPOOL FOR TRACK STRINGER
H. 2
SPOOL FOR BRACES
H. 3

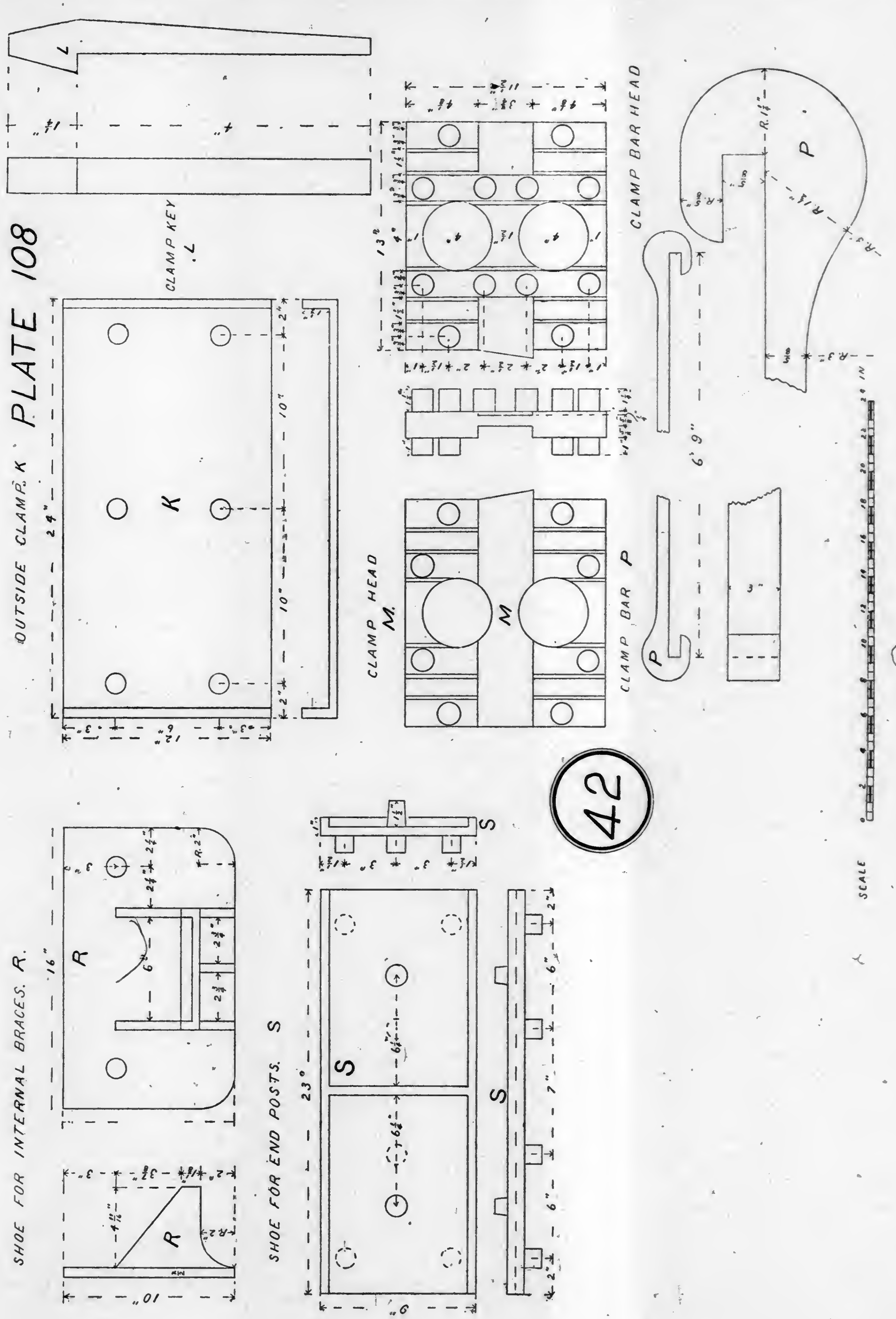


PLATE 108
OUTSIDE CLAMP. K
CLAMP KEY. L
CLAMP HEAD M.
CLAMP BAR HEAD
CLAMP BAR P
SHOE FOR INTERNAL BRACES. R.
SHOE FOR END POSTS. S
SCALE
42

of the disturbed strata observed by volcanic flues, recent drifts and a dense forest is not so materially affected or altered by geological changes as one might suppose, while undoubtedly many changes and faults have taken place, which, as a matter of course, is a natural consequence in a volcanic and mountainous country. But, on the other hand, we find it adds greater advantage for mining purposes, as also in qualities, to find the measures more or less influenced by geological manœuvers, making them practically available for commercial value and rendering the same easy to mine, while, at the same time ; we also find the measures in which the veins are described tilted about suitably in various degrees of angles, from 20° to 85°, as seen in the Wilkinson, Green River and Raging River coal-fields, and east of the mountains, so as not to interfere with the working of the coal beds, providing proper mining methods are used. I have seen many mines where a suggestion would result in the mining of the coal in better shape for marketable use. The region over which this deposition occurred has since been the scene of mountain-making and upheavals of stupendous volcanic eruptions and enormous erosions. Thus we see that the diversities and changes in coal measures which have occurred in the form of anticlinal axis, etc., are preferable in schemes of the working mines to the ordinary flat-vein coal-fields, as natural ventilation can be had. The lifting of coal, also water, can be all done at a small cost, if the field to be operated is studied in advance.

Another feature which is to be added to the Washington coal-fields, and one which is important, is the timber resources, which exist in vast quantities and in places very heavy, and are composed of fir, cedar, hemlock, spruce and maple. The same can be used for timbering in mines, where large sticks are required for props, etc. The timber resources in this State invariably accompany the coal measures, the latter being without exception overlaid with good standing timber, while in many other States the contrary is the rule, as in the Montana and Wyoming coal-fields, where the timber is very light and sparse.

The definition of the boundaries and extent of the Washington coal-fields, although a great many areas have been given, is correspondingly difficult, and in some locations and directions is an impossible task, although a description of the boundaries and approximate area will not be amiss, and will be near enough for exactness. The coal-fields or the carboniferous area extend from beyond the British boundary south almost to the Columbia River, and from the Pacific Ocean eastward to the foot-hills of the Cascade ranges, and east of the Cascade ranges, beginning at the foot-hills, 25 miles to a point or line running north and south parallel with the ranges, varying from 800 to 5,000 ft. in altitude above the sea level, but buried, on the one hand, beneath recent gravel beds and overflowed, on the other, by eruptive masses ; within the boundaries of the above described lines of 8,000,000 to 10,000,000 acres of mineral lands there are probably from 600 to 700 square miles of coal lands, of which a slight portion only is yet developed. The coal ranges in quality from a semi-anthracite up through the other qualities of coals, such as bituminous, blacksmithing, lignites, gas and coking coal, and is in inexhaustible quantities. The best sections are those of the Wilkinson and Green River fields, where large amounts are shipped yearly, as also from the Franklin mines, Roslyn and Cle-Elum coal-fields and a great number of other successful operating mines which could be mentioned, some of them turning out from 50,000 to 200,000 tons annually. There are over 20 mines in operation, with the prospect of the opening of three new coal-fields this year.

While there are many varieties and qualities of coal, there are also many different analyses, but an analysis of one is approximately that of all. In this case it is a bituminous coal having upward of 59 per cent. of fixed carbon and, in some cases, as high as 66 per cent. ; volatile matter, 28 per cent. ; ash, less than 5 per cent. ; sulphur, none. With the lignite we have excellent grades and qualities, which surpass the lignite seen in many other sections of the country. Where I have observed, the quality and grade of the lignites in these sections is probably due to action of a volcanic nature influencing the character of the coal, thus producing a hard, brilliant coal of moderate heating power. It finds a ready market in all cases where the demand for cleanliness and cheerfulness overrules the economy of the greater heating power of the more highly bituminous coal.

On the semi-anthracite of the Natchez and Cowlitz Pass coal-fields extensive measures and croppings of large veins of coal have been discovered, the strike and pitch of which extend for several miles, forming anti and monoclinal axis in basins of unknown area, and showing good analysis of the strongest indication for the best uses and purposes of coke-making. This section of the country lies dormant in one of the most secluded and remote parts of the mountains. A railroad has been talked of to open up these fields of coal, as it is deemed desirable to tap these fields, owing to the coking and bituminous qualities thus recommended. The coal in this region is probably the result of volcanic rocks running in contact with the coal measures, as faults and as intrusive dikes. They have modified the character of the coal from its original state by pressure and heat, and the influence of a superficial flow would in both these respects be less than that of molten rock before extrusion. Thus these beds of coal have been altered to semi-anthracite of a brilliant luster and an anthracite fracture, and in some places the change is sufficient to produce a bituminous or coking coal.

Here we have reviewed the several kinds of coal, qualities and probable area. In conclusion, I would add that, while at present the Washington coal is generally used for steam and domestic purposes, the general quality of other coals so far discovered in this State is found to be adapted more particularly for making gas and coking purposes. In either case the coal is very desirable and valuable.

LOCOMOTIVE BOILERS WITHOUT STAY-BOLTS.

In the April number of the JOURNAL there was published an abstract of a paper read by Herr Lentz before the German Technical Railroad Union, giving a number of designs for locomotive boilers with corrugated tubular fire-boxes. At a later meeting some comments were made and some further plans presented for fire-boxes without stay-bolts, by Herr Bork, Locomotive Inspector of the Thuringian Railroad, and an abstract of his remarks is given below :

The endeavor to simplify the locomotive boiler is of great importance, especially when at the same time economy in first cost and maintenance can be secured, with greater security against explosion. He had himself been studying this question for a number of years, and now presented some of the results of his work.

In connection with Herr Lochner he had in 1880 prepared a plan for a locomotive boiler for the Thuringian Railroad, which in many points substantially resembled the plans of Herr Lentz. This plan is shown in the accompanying engravings, fig. 1 being a longitudinal section ; fig. 2 a horizontal section ; fig. 3 a cross-section through the combustion chamber ; fig. 4 a cross-section through the fire-box. In place of the usual form of locomotive boiler, with a copper fire-box strengthened by heavy crown-bars and stays, there is a cylindrical boiler, with a tubular fire-box. This fire-box was not corrugated, like those of Herr Lentz, but was a plain cylinder of iron strengthened by two rings or bands of wrought iron, as shown in figs. 1 and 2. The fire-box is connected with a circular combustion chamber, while the barrel and tubes are the same as in an ordinary boiler. The combustion chamber is closed above, on a level with the top of the fire-box, by a fire-brick arch, as shown in figs. 1 and 3, and is, besides, built up at the side with fire-brick. Between these fire-brick sides and the outside plates of the boiler are air-spaces which serve a double purpose, both preventing any possible loss of heat and providing channels through which a secondary supply of heated air can be thrown into the chamber. At the lower side the combustion chamber is provided with a door or man-hole, by which ashes carried over from the fire-box can be re-

moved, and which also serves to make the tubes accessible for inspection and repairs.

In the forward part of the tubular fire-box there is a fire-brick bridge held in place by two iron stay-rods passing through it, as shown in section in fig. 1. The grate is back of this bridge, and is nearly in the center of the

bustion attained by the use of the combustion chamber and the secondary air supply.

These considerations, with the fact that the experiments of Herr Verderber on the Hungarian State Railroad had proved that a fire-box lined with fire-brick can be used without reducing the steaming qualities of a boiler, led to

Fig. 1

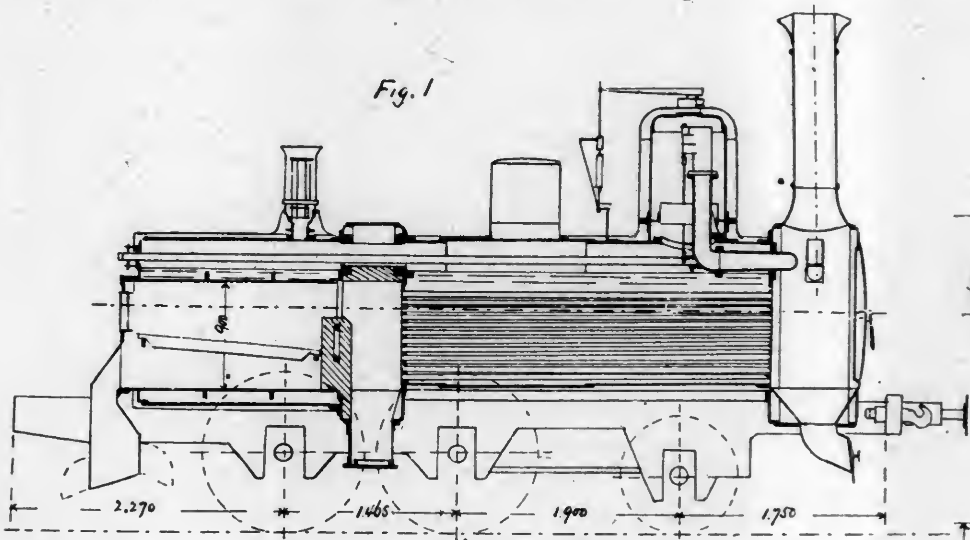


Fig. 3

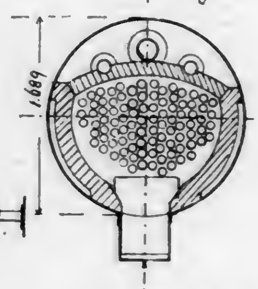


Fig. 2.

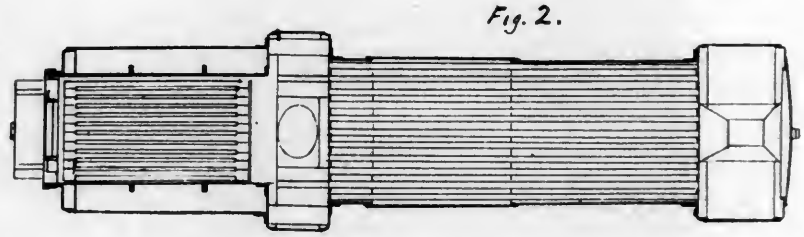
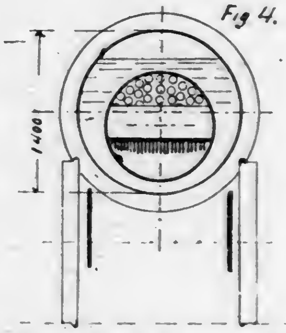


Fig. 4.



tube, leaving the lower half as a space for ashes. The rear end of the tubular fire-box is closed by an iron plate, strengthened by angle-irons, and having two openings, one above for the fire-door, which is of the ordinary pattern, and one below for the passage of the ashes. Finally, there is an ash-pan or box attached to the rear end of the boiler underneath the foot-plate; this ash-pan is provided with two doors, the upper one being used for the removal of the ashes and the lower one for the admission of air to the fire-box as required.

The advantages claimed for this plan of boiler are the absence of the heavy and expensive system of braces and

the rebuilding of the boiler of an old locomotive on the Thuringian Railroad on the plan shown in figs. 5 and 6; fig. 5 being a longitudinal section and fig. 6 a cross-section.

The original outside fire-box was used as a casing for the new fire-box, which was built up of good fire-brick, so arranged as to leave an air-space or channel between the brick and the outside casing. The fire-door and grate were arranged in their old places. The boiler barrel was lengthened a little, so that it projected into the fire-box about $4\frac{3}{4}$ in. The rear end of the barrel was closed by the copper tube-plate, in which the tubes were secured in

Fig. 6.

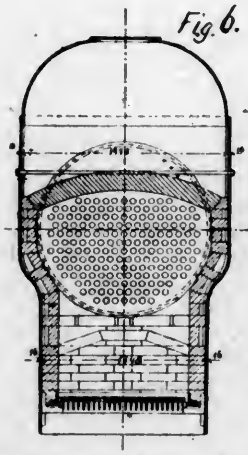
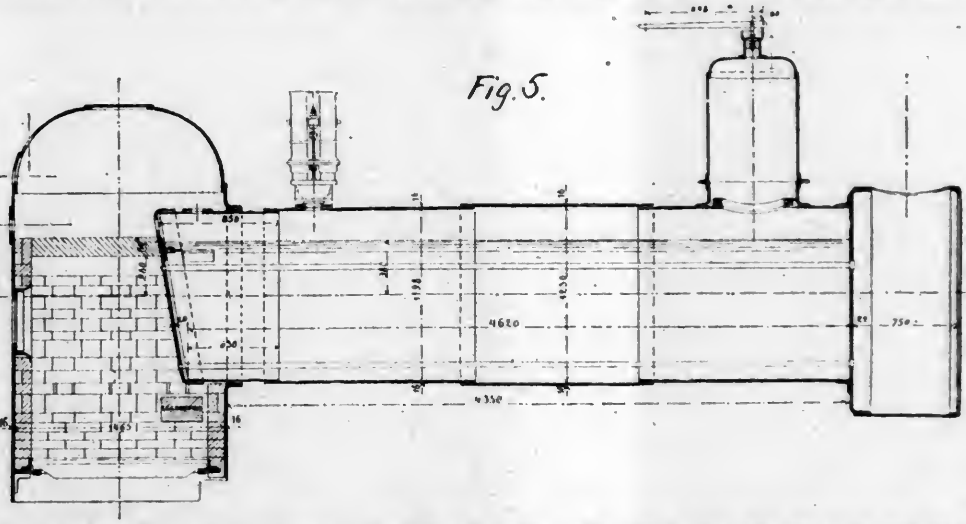


Fig. 5.



stay-bolts required for the flat surfaces of the ordinary fire-box; the capacity of the tubular fire-box to resist great pressures, owing to its form and its comparatively small diameter; the absence of the liability to crack, caused by the uneven expansion in the flat surfaces of the rectangular fire-box; and finally, the very complete com-

the usual way. The total heating surface was nearly as great as that of a boiler with the ordinary fire-box, owing to the increased length of the tubes. In this way a boiler was built without the stay-bolts usually required.

The locomotive with this boiler was put into service about the end of 1879, and was employed in regular work

until 1886. The experience gained during these years showed that the apprehension felt that the shocks experienced on the road in service might affect the durability of the boiler were unfounded. By the use of good materials in the first place long life was secured for the fire-box. The boiler steamed well, and the radiation of heat from the fire-box casing, or outer fire-box, was not greater than in an ordinary locomotive. The tubes and the tube-sheet kept in good condition, but the latter had to be renewed after about three years' service. The reason for this was that, owing to the very rapid formation of steam on the heating surface of the tubes nearest the tube-sheet and the use of bad water, a considerable deposit formed on the lower part of the sheet.

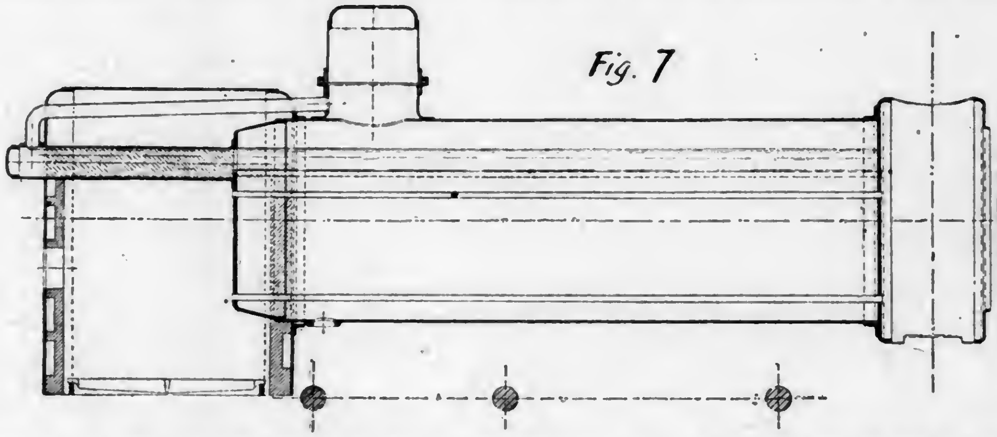


Fig. 7

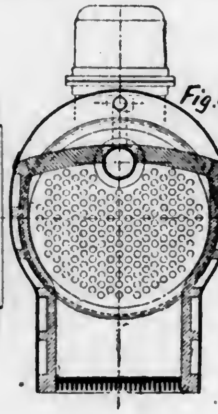


Fig. 8.

It is understood that on the Hungarian Railroads complaint was made that with the fire-brick lined fire-boxes there was difficulty in keeping the tubes tight. The reason for this was probably that the tube-sheet was carried back too far, bringing it too near the fire-door. On the Thuringian Railroad where, as stated, the boiler barrel projected into the fire-box only 4¾ in., there was no more trouble in keeping the tubes tight than in an ordinary fire-box.

The overheating and consequent injury to the lower part of the tube-sheet can be prevented, and for this purpose a boiler has been designed for a locomotive of the standard pattern in use for freight service on the Thuringian Railroad, which has six coupled wheels. This boiler is shown in figs. 7 and 8; fig. 7 being a longitudinal section and fig. 8 a cross-section.

Of this boiler it need only be said that the rear end of the boiler barrel, projecting slightly into the fire-box, is cone-shaped. In this way it is believed that the deposit of incrustation against the lower part of the tube-sheet will be avoided, and the lower row of rivets protected from the direct action of the fire. At the end of the cone-shaped part of the barrel a man-hole is placed through which any deposit can be removed. From the boiler also a water-tube extends through the fire-box which will add to the heating surface. From this water-tube steam will be conveyed by a steam-pipe running from its outer end directly to the steam-dome, as shown in fig. 7.

The simplicity of construction of these boilers is so great, that their first cost will not be much more than half that of the ordinary locomotive boiler, while the experience had with that already in service indicates that the cost of maintenance also will not be over half. The great saving which will thus be secured in locomotive expenses hardly needs to be pointed out.

Commenting upon the paper of Herr Bork, Counsellor Reuleaux said that this question of the construction of boilers was of too great importance to be neglected. The experiments of Herr Almgren on the Swedish State Railroads indicated that the usual calculations of heating surface and steaming capacity were based on an error. With proper construction the heating surface could be considerably reduced without affecting injuriously the steaming qualities of the boiler. In consequence of these experiments a system has been adopted in Sweden in which the sides of the fire-box are built up with fire-brick, provided with air-spaces or channels, as in Herr Bork's boiler; the passage of air through these is regulated by a simple arrangement of dampers.

With this arrangement the boiler is a simple cylinder, to which the fire-brick lined fire-box is attached at one end and the smoke-box at the other. The only flat surfaces are the tube-sheets, which are practically so bound together by the tubes that they require little additional bracing. Already such improvements have been made in manufacture that a boiler barrel can be made of a single plate, and it is believed that the longitudinal riveting even can be dispensed with and the boiler barrel made of a single piece, welding taking the place of the rivets.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

VI. PETROLEUM PRODUCTS (*Continued*).

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page* 181.)

It will be observed in reading the specifications that the fire test as a means of determining the quality of petroleum products, which was discussed to quite an extent in the last article, especially as applying to 150° oil, applies also to all the other grades of petroleum products generally used by railroads. The 150° oil is the most sensitive, and requires that the manipulation and attention to the various variables mentioned in the last article should receive the greatest care. With the other grades of oil some of the various variables mentioned are not as prominent. All the variables mentioned, however, have their influence, and can by no means be completely ignored. It will also be observed that the two burning oils—namely, the 150° and 300° oils—have both the flashing and burning points specified in the specifications, while the other oils only have the flashing point specified.

It is a question which has been much discussed among users of the petroleum products whether there was any use in taking anything more than the flashing point, since this really measures the dangerous quality of the oil. We are inclined to think the flashing point is abundant to protect the interests of the railroad company, provided

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the Journal for December, is on the Work of the Chemist on a Railroad; No. II, in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No V, in the April number, on Petroleum Products. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these Contributions to Practical Railroad Information of special value in indicating the true character of the materials they must use and buy.

the taking of the flashing point is surrounded with sufficient precautions; but as a means of additional security, and especially as a means of neglecting no precaution that could fairly be made use of to prevent accidents with the burning oils, we still adhere to the burning point as an essential feature. Moreover we have found a few oils the flashing and burning points of which were very close together, and from the nature of the distillation we would expect this would be true of oils which represent a very small fraction of the original petroleum, so that taking all things into account, it has been deemed advisable to maintain the burning point likewise as a test for all petroleum products used for burning.

The petroleum products used for lubrication—namely, paraffine, well, and 500° oils—are so high in flashing points, that there is very little danger of fire from their use, and the flashing point sufficiently determines the presence of ingredients which are too low to be used advantageously as lubricants. Accordingly for all the petroleum products used for lubrication we take only the flashing point. It will also be observed that except the 150° oil, all the petroleum products are heated at the rate of 15° per minute, instead of 12° per minute. Otherwise than this the test is made in exactly the same way for the other petroleum products as for 150° fire-test oil.

In concluding the discussion of the fire test of petroleum products, we will say that we are hardly satisfied with any method that we know of in practical use for determining the fire test of petroleum. Methods have been proposed, however, which to our minds are much more satisfactory—notably, the putting of the oil in a rather deep, small, cylindrical vessel, heating it to the temperature decided upon, and then passing air slowly through the oil, with the idea of carrying out of the heated oil any vapor that may be readily formed at that temperature, and then applying the test flame to see whether enough vapor has been carried out to cause a flash or slight explosion. The oil would pass test if no flash occurred; would not pass test if a flash occurred. We are planning some experiments on this method of testing, and are inclined to feel from our present knowledge of the case that this method will give results which will be more satisfactory and give greater certainty as to the quality of the oil used than any method we now know of in practical use. The limitations and details of the method we have not yet fully worked out, and are therefore unable to give anything more positive in regard to it at present.

Returning to the specifications, it will be observed that all the oils except the 500° oil have a cold test specified. The question of cold test has been discussed somewhat in the previous article on Lard Oil. In addition to what is stated there we will add that the difficulty of the separation of the various constituents when under the influence of cold is much greater in the petroleum products than in lard oil—that is to say, every one of the petroleum products with which we are familiar has a greater range in the congealing points of the various constituents of which the product is composed than lard oil, and if, as has been previously stated, the one which has the highest congealing point solidifies first, the difficulty of making a cold test by the ordinary method of seeing when the test sample is solid is still greater with the petroleum products than with lard oil. We accordingly make our cold tests of the petroleum products in exactly the same way as for lard oil—namely, freeze the sample if possible with a thermometer suspended in the oil, and then determine the point at which the mass will run from one end of the bottle to the other, calling the reading of the thermometer at that point the cold test of the oil. The two petroleum products which are used for burning do not, however, admit of this method of testing, since the 150° oil especially is so low in congealing point that it is very difficult to freeze the mass. We accordingly for this purpose expose the oil to the temperature mentioned in the specifications, and see if it shows any cloudy appearance, due to the congelation of any of the paraffine wax, or any material in the oil which is solid at that point. With 150° oil we use a mixture of ice and salt, which gives a temperature approximately zero, and as stated in the specifications, the oil must remain clear for ten minutes at the temperature of this freezing mixture. Many of the 150° fire-test oils of the market will stand this test without any difficulty whatever, some of them standing as low as 20° below zero, before they show a cloudiness. On the other hand, many of the 150° oils of the market become cloudy or opaque, even 10° or 15° above zero. The necessity for this specification for 150° oil is due to the fact that this grade of oil is used on the Eastman Heater Cars, and if the oil does not stand the cold test of the specifications, the solid particles clog the feed, and cause serious difficulty when the weather is cold. To such an extent is this the case that for a long time the Eastman Heater Company specified a special oil for use on their cars. We did not find, however, that this special oil was better than oil which would pass our specifications, and accordingly we decided that all oil of this grade must stand this test. There is no difficulty whatever in making 150° oil which will stand this test, and we have very little difficulty with shipments.

In the 300° fire-test oil, as will be noted in the specifications, the cooling mixture is simply ice and water, which is exceedingly simple. The cold test of paraffine and well oils has, perhaps, been sufficiently commented on, except that this is the proper place to say that there is a belief in the trade that an oil which has been once congealed will never again give the same cold test. We have had considerable difficulty due to this belief. Shipments of well oil especially would be received, and samples taken which would not stand the cold test required, and which, by tests made by other parties, it did stand. The explanation of the shippers on this point was that the can bringing the sample to us had been subjected to cold in transit in the baggage car, and the oil frozen, and that their experience was that any oil after it had once been frozen would never have the same cold test again. This peculiarity caused us considerable difficulty until we found how the matter stood. The explanation given by the shippers according to our experience is not correct. An oil can be frozen and thawed as often as one chooses without affecting its cold test at all, and we have obtained exactly the same cold test from the same kind of oil after freezing and thawing it a good many times. The explanation of the difficulty is as follows: If a can carrying an oil sample is exposed to the cold in transit, especially if the cold is rather slowly applied, part of the oil near the outside of the can congeals, crowding the more limpid portions, as has already been explained, to the center of the can. The cold might be sufficient to congeal all the oil in the can. When it is brought into the laboratory, the can is usually allowed to stand a little while until attention can be given it. Of course during this time it was thawing out and thawing slowly. When now the oil is taken in hand for test, it may or may not be wholly thawed out, and that portion of the oil which is poured out for test under these conditions will not therefore be the same as if all the oil in the can is limpid and the oil has been thoroughly mixed. We have taken successive samples out of a can treated in this way, and obtained a different cold test on each successive sample. On the other hand, if the oil in the can has all become limpid, and then is thoroughly mixed, so as to become uniform in all parts of the can, the cold test of successive samples will be the same, and furthermore the same can may be frozen and thawed as often as one chooses without affecting the cold test, provided before making the test the oil in the can is thoroughly mixed so as to become uniform throughout. There is also another cause of discrepancy in cold test between the tests made by the manufacturers or shippers and the tests made by the laboratory. If the oil has become congealed in the barrels in transit, it is entirely possible that sufficient separation of the constituents may take place to affect the cold test. Our instructions to the men who take the samples are to roll the barrels about in the winter season before the sample is taken for test. We usually have very little difficulty from this cause, since our specifications require zero oil in the winter, and also since the material is usually not very long in transit. In colder climates it is entirely possible that the difficulty of the oil congealing in the barrels might become a very serious one, in which case it would be necessary in all cases to have the oil thoroughly thawed out and the barrels rolled

around, and possibly the heads of the barrels taken out and the oil stirred, in order to get a fair sample for test.

The specific gravity of petroleum products is a very common test in the trade, and this, together with the fire test, are the usual means of determining the quality of the oil which the trade employs. It will be observed in our specifications that we have paid no attention to the gravity in the two oils used for burning, nor in the 500° fire-test oil, used, as will be explained later, for cylinder lubrication. The paraffine oil and the well oil have tests for gravity. It is claimed by some well-known refiners of petroleum that the test for gravity also should be applied as a means of determining the quality of burning oils. The test for gravity has something of the same effect, however, as fire test—that is to say, those constituents of the petroleum products which are lowest in fire test are also lowest in gravity, and in our experience we have not found it necessary to specify gravity for the burning oils. There is another phase to this question, however. The facility with which the oil flows up the wick unquestionably bears some relation to its value as a burning oil, and we believe some of the refiners claim that there is a relation between the gravity and the capacity of the oil to flow up the wick. The tests which we apply, however, are those which our experience has indicated as essential to give us the product that we want, and as no necessity has ever arisen in our experience indicating that it was essential to take the gravity of the burning oils, nor to devise tests for the rate of flow up the wick, we have allowed these two subjects to rest until some necessity should arise, holding ourselves quite at liberty to add further tests to those now in force, if occasion demands. In lubricating oils there is believed to be a relation between the gravity and the value as lubricants. Our experiments indicate that with the same kind of oil, the heavier the gravity the more viscous the oil, and consequently it will give somewhat higher friction. On the other hand, the lighter the gravity the less viscous the oil and the less friction. Extremes in either direction are dangerous—that is to say, if the oil is too viscous, much power is lost in overcoming this viscosity; if the oil is too limpid, the surfaces are not held far enough apart to prevent rapid wear and danger of heating. Accordingly an attempt has been made in our specifications to reach a mean between these two extremes, so far as this mean is measured by the gravity. With oils of different kinds, however, we have never succeeded in discovering any relation between the gravity and the lubricating power. For example, a lard oil of the same gravity as petroleum does not give the same results on test; or again sperm oil does not give the same results as paraffine oil of the same gravity, and in truth all our experiments have failed to show, when oils of different natures are mixed together, or are tested alone, that there is any relation between the gravity and the lubrication. With oils of the same kind, however, there is some relation between the gravity and the lubricating power. There is very little difficulty in getting in the market paraffine and well oils which come within the limits of our specifications, and a long experience has indicated that so far as gravity goes oils meeting our requirements give very good results.

In regard to the remaining tests for petroleum products, the two burning oils are required to be "water-white" in color, and there are not a few among the refiners who think that a yellow oil gives equally good results in burning as "water-white" oil, and we are hardly prepared to dispute the position. The reason for demanding "water-white" oil is that by the ordinary method of distillation, the oils contain some tarry matter, unless this is removed, as has been previously described, by treatment with oil of vitriol; and as the demands made on our burning oils are rather severe, we have felt that we were entitled to all precautions possible to prevent clogging of the wicks, the tar, as is well known, remaining in the wicks and causing them to crust. We accordingly demand "water-white" oil. Many times the market falls a little short of "water-white" oil, and what is known as "prime white" is frequently sent in place of "water white." The distinction is not very sharp, and we are ofttimes compelled to accept material that is somewhat less than "water white."

The question of cloudy oil is a very serious one. The most common cause of cloudy oil is due to the following points in manipulation at the refineries where the oil is barrelled. The barrels, in order to make them tight, are treated on the inside with a dilute solution of glue. It sometimes happens that owing to carelessness either the gluey solution is not wholly drained out or the barrel is not allowed to become sufficiently dry before the oil is put in. In this case the gluey matter, owing to the shocks of rolling and shaking incident to loading on cars and transportation, becomes thoroughly mixed up with the oil, giving it an opaque or cloudy appearance, which cloudy appearance is very slow to disappear by settling. These little particles of glue or glue and water finely divided, suspended in the oil, are when the oil is used for burning soaked up into the wick, and clog it, as will be readily understood. We have had much difficulty from this cause, and the rule is enforced quite strenuously that cloudy oil will not be received. The sample sent for test being, as the specifications state, a sample from a single barrel chosen at random, and the bad condition of a barrel when it is full being characteristic of any barrel in the shipment, it does not always happen that the sample which we receive shows a cloudy appearance, although other barrels in the shipment may do so. To obviate this difficulty, the instructions to the men at the oil houses are that all barrels containing cloudy oil must be returned to the shippers, they themselves performing the inspection necessary to determine this point. Long standing in a quiet position will cause most of this material to precipitate, but the supply carried at most of the oil houses demands that the oil be used moderately quickly after it is received, and consequently we have preferred to return cloudy oil rather than attempt to use it.

The viscosity test applied to the paraffine and well oils has something of a history. For a number of years the Pennsylvania Railroad Company has made tests on the Thurston oil-testing machine of the well oil samples especially, this being, perhaps, the most important oil used for lubrication. It was the custom to ask the manufacturers to furnish a sample of such oil as they were willing to furnish for the ensuing month's supply. These samples were tested in the laboratory, as to whether they would fill the specifications given in the printed sheet. They were also tested on the oil-testing machine. The information from both these sources was sent to the purchasing department, and in placing orders, first all samples which did not fill the requirements of the printed specifications were thrown out. Those that were left were examined in the light of the lubricating test, and orders placed on those samples only which came within certain limits of friction. Neither too low nor too high friction was desired. This test was used for quite a length of time, but the manufacturers complained that they had no means of duplicating these tests, since duplicate results from different machines are very hard to get, and therefore they were somewhat in the dark as to how to meet the requirements of our lubricating test. If they sent a sample of oil, it might fill the lubricating test and it might not, and they had no information to enable them to modify the oil so that it would meet the requirements. In view of this state of affairs, which was regarded by ourselves as a just criticism, the viscosity test was devised. It is of course assumed in this test that the viscosity of the oil is an important element in the friction which results when the oil is used in service, and it becomes quite an interesting question as to whether the viscosity test would give results corresponding to the results obtained in actual service. We hope to prepare some articles on lubrication, and this question will then be discussed *in extenso*. Meanwhile it is, perhaps, sufficient to say that for a number of months the viscosity test has been supplemented on the same sample by a test on the oil-testing machine, and while there is no absolute agreement between the results of the two in case of every oil, yet the discrepancies are so narrow that no oil which would be rejected on lubricating test would be accepted on viscosity test, and *vice versa*. In other words, the two tests run very closely together. We are quite well aware that elaborate viscosimeters have been prepared so delicate that even the presence of a small amount of lighter oil added to the oil under test will show. These viscosimeters are unquestionably of great value,

but for a practical test which could be applied by the manufacturers themselves, and which would at the same time give indications sufficiently accurate for the general use of railroads, we think the viscosity test as we employ it is sufficient. In developing this test we found one or two points which were very interesting. Of course it was essential that the pipettes used should be capable of duplication, and any one who has tried to get pieces of glass apparatus which were exact duplicates of each other knows that this is almost impossible. However, after making a large number of experiments, we found that the size of the bulb of the pipette and its length, and the size and length of the tube above the bulb, have very little influence on the test. On the other hand, the length and size of the tube below the bulb, as well as the size of the aperture, are of very great importance. It was almost impossible to get pipettes that would give the same results, as they are ordinarily graduated. On the other hand, if the pipettes were regraduated so as to hold just 100 cubic centimeters to the bottom of the bulb, the difficulty due to the length and size of the tube below the bulb disappeared. We now buy our pipettes regraduated by the makers, and the lower aperture adjusted as above described, and have no difficulty in getting duplicate tests on the same oil with different pipettes. We use a stop watch, which gives us results to within a second. It will be readily understood how the temperature of the oil and the temperature of the room have an influence on the test; the higher the temperature the greater is the limpidity, and the more rapidly the oil will run from the pipette. We always stir the sample after it is heated to the required temperature, so as to be sure that it is uniform throughout.

The statement in the specifications that paraffine oil must be pale lemon color is more a concession to the paraffine oil refiners than an essential prerequisite. Oils are offered in the market in competition with paraffine oil which are redder than paraffine, and the refiners think it unjust that these oils should be allowed to go in under the same specifications as paraffine oil, since they are more cheaply made, and do not have quite the same qualities as genuine paraffine oil. Accordingly the color was made an essential part of the specifications. Smith's Ferry oil is really a species of well oil, except that it is not dark in color. It has also a slightly lighter gravity, but otherwise has much the same physical properties as the well oil. We have obtained very good results with this oil in place of paraffine oil during the summer season, but as it is impossible to make Smith's Ferry oil which will stand the cold test required in the winter, we do not attempt to use it during the cold weather.

The flashing point of well oil is varied, as will be observed, according to the time of the year. This we have found to be essential, since in the winter season it is impossible or extremely difficult to get a cold test such as is essential for use at this season of the year with a flashing point that is required during the remainder of the year. We have seen many samples of oil which would stand our cold test that did not flash below 249° Fahrenheit, but this is not generally the case, and accordingly we drop off a little in flashing point, to enable some of the lighter constituents of the petroleum to appear in the well oil, thus accomplishing two purposes: First, securing a better cold test, since the lighter portion of the petroleum stands cold test better than the heavier portion, and also second, since the lubrication in the winter is done at a lower temperature, we can use more limpid oil than we can in the summer. The viscosity of the oil in the winter and in the summer is quite different, and the effect of this on train resistance is very marked. A sudden cold snap with summer oil in the boxes diminishes the number of cars in a coal train sometimes by as many as three or four. This point in regard to the effect of the viscosity of the oil on train resistance will be discussed still further when we come to some articles on lubrication.

The precipitation test for the well oil and the 500° fire-test oil is for the purpose of excluding tarry and suspended matter. From the method of distillation used in refining petroleum products, it often happens, especially if high heats are used, that a very heavy viscous substance occurs in the oil sent out by the refiners as lubricant. Moreover, it seems probable that what are known as "still bottoms," which are the very heavy parts of the petroleum left in the still when making certain kinds of oil, are mixed with the lubricating oils by certain refiners. We have seen oils which were simply nothing but mixtures of slightly reduced crude with "still bottoms." These still bottoms and, indeed, the tarry matter itself are objectionable as lubricants, and we have accordingly for a long time tried to get some means of rejecting oils which contained these in large amounts. The old test used for this purpose was to pour a little of the oil on a piece of glass and allow it to run down in a stream off the edge. On holding the glass up to the light, if black specks or clots of blackish-brown appeared, the oil was regarded as inferior, and was rejected. This test worked very well for a while and completely excluded the still bottoms, but after a while the manufacturers learned to mix enough of the inferior material with the oil to give a pretty dark brown, and as there is no means of distinguishing between different shades of color, we found we were receiving inferior oil under this test—that is to say, our specifications rejected oil that was darker than reddish brown; but as reddish is not a definite color, we found our shipments were constantly becoming more and more of a blackish brown, without our being able to draw a distinction sufficiently sharp to enable us to reject shipments without dispute. Still further we have once or twice found an oil which was all right in color, but which was apparently a mixture of heavy residues from some part of the distillation and lighter oils, and which was a very poor lubricant. Accordingly the precipitation test was devised. This test is based on the fact that the heavier members of the paraffine series are insoluble in the lighter members. The tarry matter and the "still bottoms," and any other inferior material in a sample of oil falls to the bottom of the vessel when the oil is mixed with gasoline, as described in the specifications. This test works charmingly and secures an excellent oil in the grades to which it is applied.

The grade of oil known as 500° oil in our specifications is what was formerly known in the market as 600° oil. It is also known under the name of cylinder stock. The flashing point and the precipitation test are all the tests which we have found it essential to apply to give us in this grade of oil all that is required.

It will be observed that the Pennsylvania Railroad specifications do not provide for the use of any of the filtered petroleum products. We have many times been asked to use filtered oils, on the ground that they were better. Our tests seem to indicate that while the oils present a better appearance, they do not in service give enough better results to pay for the increased cost, and accordingly we do not attempt to use any of the filtered oils.

In addition to the oils previously described in this series of articles, specifications have been prepared for tallow oil and neatsfoot oil. Neither of these oils, however, have been able to compete in price with the two grades of lard oils, and we have accordingly used very little of them during the last fifteen years. If at any time the relative cost of these oils or, indeed, of colza oil, peanut oil or rapeseed oil should enable these oils to compete or be used with economy, specifications would be prepared for those for which we have no specifications as yet, and the specifications already prepared for tallow oil and neatsfoot oil would come into prominence.

It will be noticed in the specifications for the various kinds of oils that a single sample of about a pint, taken from any barrel at random, is sent for test, and that this represents the shipment, and that the shipment stands or falls on this single sample. Some of the manufacturers and dealers have thought our method of sampling was hardly fair, that in reality the sample ought to be a composite one, a little being taken from each barrel. This question has been much discussed, and the reasons that have led us to the practice which we have—namely, of taking a sample from a single barrel selected at random—are, first, it is no small job to sample a lot of 50 or 100 barrels of oil, and our force at the oil house would hardly warrant us in going into such extensive sampling; and second, the oil in the shipment ought all to be of the quality ordered, and if it is all of the quality ordered, and

is uniform, a sample from a single barrel is as good as a sample from all the barrels. There is a phase of this question, however, which will bear a word further. We have had shipments in which all the oil except two or three barrels was of uniform grade and quality, apparently all except the two or three barrels having been barrelled from the same tank. This sending of a small amount of inferior oil happens in this way. An order calls for a little more oil than happens to be in the tank at the shipper's works, and to fill out the order two or three barrels are taken from another tank, which in some cases have been inferior oil. It is fair to say that in this case there is a chance for injustice to ourselves, for if by chance the sample which we get for examination comes from one of the good barrels, the whole lot is accepted, and we actually get some inferior oil in place of the good oil that was bought. On the other hand, if our sample comes from one of the inferior barrels, the whole shipment is rejected, and the shipper has to pay the return freight. Our position in this matter has been that if the shippers were willing to take the risk of our getting a sample from an inferior barrel, we were willing to take the risk of our getting a sample from a good barrel. Fortunately for ourselves, in two or three cases which we know about from subsequent investigation, we have happened to get our sample from an inferior barrel. In one case which we specially have in mind, the manufacturer had an order for 45 barrels of lard oil of the best grade. The foreman at the factory had only 42 barrels of that kind of oil in stock, and being anxious to make the shipment, filled out the order with three barrels of inferior oil. Our sample came from one of these three barrels, and the whole shipment was rejected. The parties made some stir over the matter, but we simply told them we were very glad the matter had turned out as it did. They of course did not attempt to uphold the foreman, but thought that a fair method of sampling would have caused us to accept 42 barrels and only returned the three. Our system of a single sample representing a shipment has worked so well that we should be very loath to abandon it. It is in reality something of a check on our receiving inferior material, due to the fact that the manufacturers know that the whole shipment goes back if perchance the sample which we have for test is inferior material. It is only fair to say that the return freight on most shipments of material costs actually more than the profit would be.

In the next article of this series we will describe at length how the oils which have been treated in the six articles of this series on oils are used, giving the mixtures and the results of our experience with these mixtures.

(TO BE CONTINUED.)

THE ESSENTIALS OF MECHANICAL DRAWING.

BY M. N. FORNEY.

(*Continued from page 184.*)

CHAPTER III.

CONSTRUCTIONAL GEOMETRY.

THE theory of mechanical drawing is based on the principles of Geometry, which is defined as "that branch of mathematics which investigates the relations, properties, and measurement of lines, angles, surfaces and solids." Therefore a person who has a knowledge of Geometry has a great advantage in learning drawing over one who is ignorant of it. The general truths of Geometry are deduced by a course of logical reasoning, the premises being definitions and principles previously established. The course of reasoning employed in establishing any truth or principle is called *a demonstration.* Thus in books on Geometry the truth is enunciated that "in any triangle the sum of the three angles is equal to two right angles," and the reasoning is then given at length to prove that this is true. As a knowledge of mechanical drawing will be very useful to many persons who have neither time nor opportunity to acquire a thorough knowledge of Geometry, it will be the aim in this chapter to explain some of the general truths and principles of Geometry which are essential in learning mechanical drawing, without giving the proof or the reasoning by which they have been deduced.*

These truths and principles will be illustrated and explained by a series of problems, which are to be drawn first with a pencil, and the lines should then be inked in as neatly as possible. In this way, Geometry and the practice in the use of drawing instruments will be learned simultaneously. Even though the learner may have a knowledge of Geometry, he is advised to work out the problems on paper for the exercise it will give him or her in the use of instruments. In doing this work "the greatest pains should be taken from the first to acquire the power of measuring and laying down measurements on paper with perfect accuracy, which is of the utmost importance in mechanical drawing. It is best to take the measurements with compasses or dividers from the rule or scale. This method is more likely to result in exact measurement than laying the rule or scale on the paper and marking from it." †

The definitions of terms which are used will be given in foot-notes. The drawings should be made double the size or twice the linear scale of the engravings—that is, a line which is one inch long in the engravings should be drawn two inches, and one two inches in the engravings ought to be four inches in the drawings. Feet and inches are designated in the engravings by single and double accent marks—thus 4 ft. 8 in. is written 4′ 8″.

The points from which measurements are to be made or to which dimensions refer are indicated by caret marks thus <———>, as shown at *c d* at the foot of fig. 24, where it is indicated that the line *c d* is 1¾ in. long, and that that is measured from the lines at the points of the carets.

As it is difficult sometimes to find prick marks of dividers or compasses, such marks and other points which are to be designated are often indicated by a small circle around them thus ⊙, or by a short line drawn at right angles to the line on which the point lies, as 1, 2, 3, 4, etc., in fig. 27.

PROBLEMS.

I.—STRAIGHT LINES.

PROBLEM 1. *To draw horizontal ‡ lines.*

Place the T-square in the position shown in fig. 21,§ and press its stock firmly against the edge of the board, and draw a line along the upper edge of the blade, and be sure that neither the stock nor blade is moved while the line is drawn. Then move the T-square either up or down the required distance that the two lines are to be separated and draw another line. Repeat this operation for each successive line.

PROBLEM 2. *To draw vertical lines.*

This was explained in the previous chapter.

PROBLEM 3. *To draw a straight line parallel to any other straight line at a given distance from it.*

First Method.—If *A B*, fig. 22, is the given line, place one side, *e f*, of the triangle *D* so as to coincide with that line. Then place the straight edge or ruler *C* in contact with the side *e g* of *D*. Then hold *C* firmly on the paper and slide *D* along the edge *e g′* of *C*, until the edge *e f* is the required distance from *A B*, as shown in fig. 23. Then draw a line along the edge *e′ f′*. In this way any number of parallel lines may be drawn.

Second Method.—If *A B*, fig. 24, be the given straight line and *c d*, 1¾ in. long, their required distance apart, with the pencil in the joint compasses, fig. 10, set the needle-point and the pencil apart a distance equal to *c d*. Then with this distance as a radius ‖ and any two points, as *e* and *f* on *A B*, as centers draw arcs ¶ of circles, 1 1 and 2 2.

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* The learner is, however, advised to acquire a thorough knowledge of Geometry, if it is possible for him to do so.

† Linear Drawing, by Ellis A. Davidson.

‡ A line in a drawing which is parallel with the lower and upper edges of the drawing-board is said to be *horizontal*. And one which is at right-angles to or square with the lower and upper edges of the board is said to be *vertical*. A line is said to be *perpendicular to* another line or surface when it is *square* with it. To say that a line in a drawing is "perpendicular" does not necessarily mean that it is *upright*, for the edges of a carpenter's or mason's square are perpendicular to or square with each other in whatever position the square is placed. *Horizontal* and *vertical* lines are *perpendicular* to each other. If a line is drawn at right-angles to or square with another which is inclined, they are also said to be *perpendicular* to each other. Thus *C′ C* in fig. 36 and *E C* in fig. 37 are both perpendicular to *A B*.

A line is *parallel* with another when they both extend in the same direction and when they are equally distant from each other through their whole extent. Thus the ruled lines on writing paper and the metal rails on a railroad are parallel.

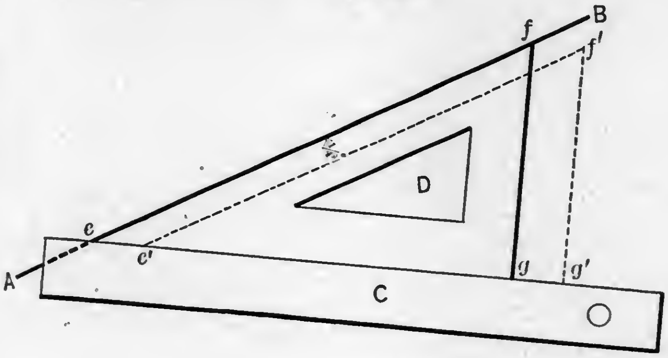
§ See the April number of the JOURNAL.

‖ A *radius* is the distance from the centre to the circumference of a circle.

¶ An arc of a circle is a part of the circumference of a circle, as, for example, 1 1 and 2 2, fig. 24.

Draw the line *G H* tangent* to 1 1 and 2 2. The straight line *G D* will then be parallel to *A B*, and at the given distance *C e* equal to *c d* from it.

Fig. 22.



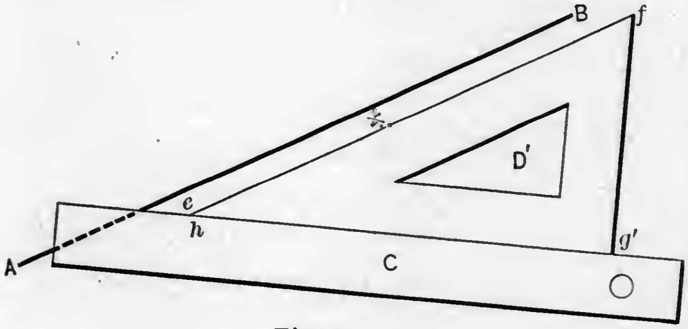


Fig. 23.

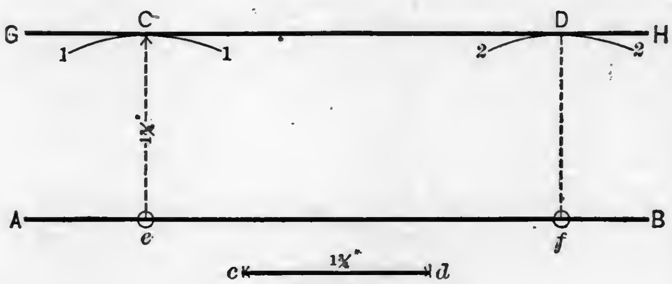


Fig. 24.

PROBLEM 4. *To draw a straight line through a given point and parallel to a given straight line.*

First Method.—If *C*, fig. 25, is the given point and *A B* the given straight line, then from *C* as a center, with *C D* as a radius, draw an arc, 1 1, touching *A B* at *D*; and with the same radius from any convenient point, *F* on *A B* as a centre, draw the arc 2 2. Draw the line *G H* through the point *C* and tangent to or touching the arc 2 2. *G H* will then be parallel to *A B*.

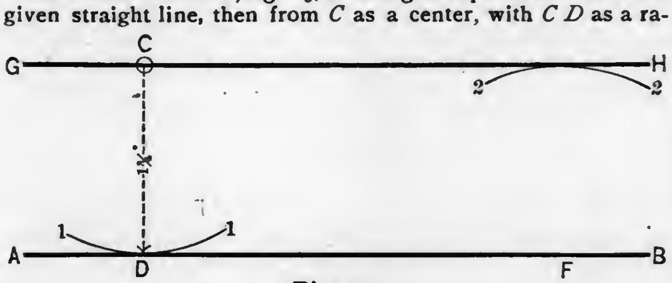


Fig. 25.

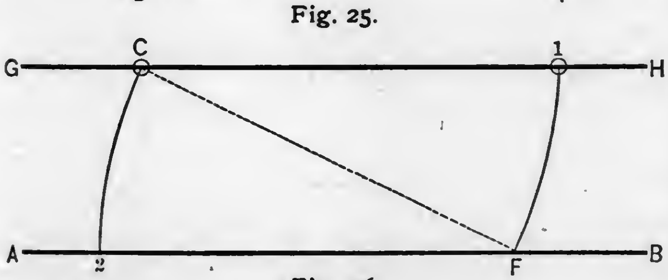


Fig. 26.

Second Method.—If *C*, fig. 26, is the given point and *A B* the given line, then from *C* as a centre, with any radius, as *C F*, draw the arc 1 *F* crossing or intersecting the line *A B* at *F*. From *F* as a center with the same radius, draw the arc 2 *C*. With the dividers or compasses take the distance *C* 2 and set it off from *F* on the arc *F* 1. Through the points *C* and 1 draw *G H*, which will be parallel to *A B*.

PROBLEM 5. *To bisect, or divide in two equal parts, a straight line of a given length.*

First Method.—Supposing the line *A B*, fig. 27, is 6 in. long, it is best to define its length exactly by drawing two short lines square across it at *A* and *B*, and exactly 6 in. apart. Then set the points of the dividers, fig. 17, apart, so that the distance between them, measured by the eye, is as nearly as possible equal to half the length of *A B*, or 3 in. Then place one of the points on the point at *B*, where the lines cross each other, and try by stepping off from that point whether twice the distance between the points of the dividers is exactly equal to the length of *A B*. If it is not, separate the points more or less, until by trial it is found that the distance between them is just equal to half the distance between *A* and *B*, and then prick a small hole in the paper at *C*, to mark the point of division.

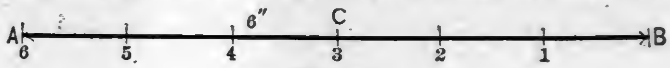


Fig. 27.

An easier method is to set the points of the dividers by a rule or scale, so as to take half the length of *A B* =* 3 in., and then by stepping off from *B* ascertain whether this measurement is precisely equal to half the length of *A B*. If it is not, see whether *A B* is exactly of the required length, and if it is, then adjust the points until they are just equal to half the length of *A B*.

Second Method.—With a radius somewhat greater than half the length of *A B*, fig. 28, and from *A* as a center, first draw arcs of a circle, 1 1 and 2 2. Then place the needle-point on *B* and draw arcs 3 3 and 4 4 so as to cross or intersect each other as represented. Then draw a straight line, *D E*, through the points of intersection of the arcs. This line will divide or "cut" the line *A B* at *C* into two equal parts. Before drawing the line *D E* it is best to mark the points of intersection† of the arcs exactly by pricking a small hole in the paper where they cross each other.

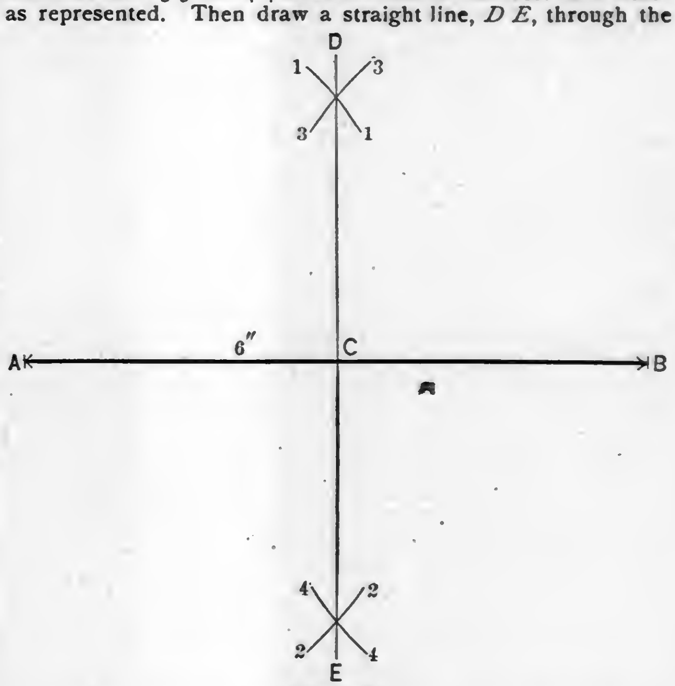


Fig. 28.

PROBLEM 6. *To divide a straight line of a given length into any proposed number of equal parts.*

First Method.—If the line *A B*, fig. 27, is, say, 6 in. long, and it is to be divided into six equal parts, set the points of the dividers apart a distance as nearly equal to one-sixth of the length of the line as it is possible to determine by the eye. Then set one point on the intersection of the short line with *A B* at *B*

* Tangent means touching. A line tangent to a circle touches it at one point only—that is, it does not cross or intersect it.

* The sign = means "equal to," and will be used hereafter in these articles.
† The "*intersection*" of two lines is the point where they cross each other.

and step off on $A\ B$ six divisions, being careful to handle the dividers very lightly, so as not to make any holes in the paper. It can thus be determined whether the distance between the points will divide the line $A\ B$ exactly into six equal parts. If it does not the points must be separated more or less until by repeated trials it is found that the space between them is just equal to one-sixth of the length of $A\ B$. When the length of the subdivisions is thus ascertained exactly, small marks should be pricked on the line $A\ B$ and short lines drawn through them to indicate the points of division.

A quicker way of doing this is to divide the length of the line by the number of divisions—in the example six—and then take with the dividers the measurement thus indicated from a rule or scale, and then by trial ascertain as before whether it will divide the line accurately into six equal parts. If it does not, the length of the line should be measured to see whether that is correct. If it is, the points of the dividers must be adjusted by repeated trials until the space between the points will subdivide the line correctly.

If there are many divisions and if their *number* can be divided equally it is best first to divide the line into a few divisions and then subdivide these. Thus the line $A\ B$, which is 6 in. long, could be laid off first into two or three equal parts, each 3 or 2 in. long, and these might then be subdivided into two or three subdivisions, each 1 in. long.

In doing such work the learner must be careful first to lay off the line $A\ B$ of just the right length and then adjust the points of his dividers with the utmost precision.

Second Method.—$A\ B$, fig. 29, being the required line, $5\frac{5}{8}$ in. long, from A draw a line, $A\ C$, of indefinite length at any convenient inclination to $A\ B$. Then from B draw a line, $B\ D$, parallel with $A\ C$, and with any convenient distance, as A 1, between the points of the dividers set off on each of the parallel lines, beginning from the points A and B, as many equal spaces, A 1, 1 2, 2 3, etc., and B 1′, 1′ 2′, 2′ 3′, etc., as the line $A\ B$ is to be divided into; in this case six. Then draw lines to unite A and 6′, 1 and 5′, 2 and 4′, etc. These lines where they cross $A\ B$ will divide it into the required number of equal parts.

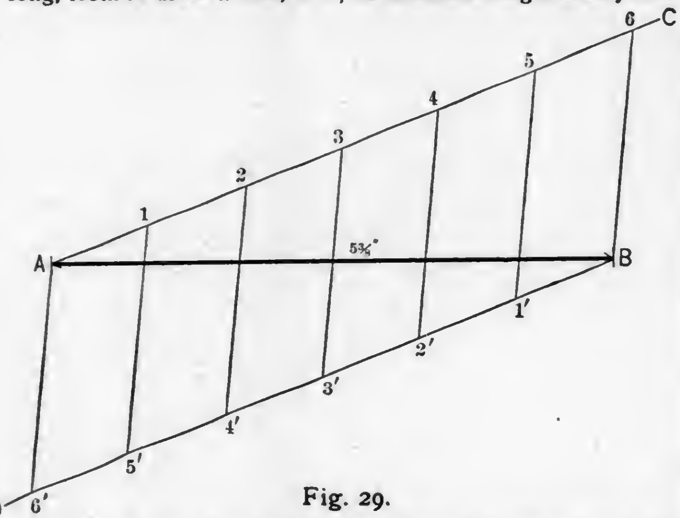


Fig. 29.

Third Method.—$A\ B$, fig. 30, being the line, also $5\frac{5}{8}$ in. long, draw $A\ C$ of indefinite length and at any convenient inclination to $A\ B$. Then from A lay off as many equal spaces, A 1, 1 2, 2 3, etc., as the line $A\ B$ is to be divided into; in this case eight. Draw a line, 8 B, through 8, the last division on $A\ C$, to B, the end of $A\ B$. Then draw lines parallel to 8B through the points 7, 6, 5, 4, etc. Where these lines cross $A\ B$ at 7′, 6′, 5′, etc., they will divide it into the proposed number of equal parts.

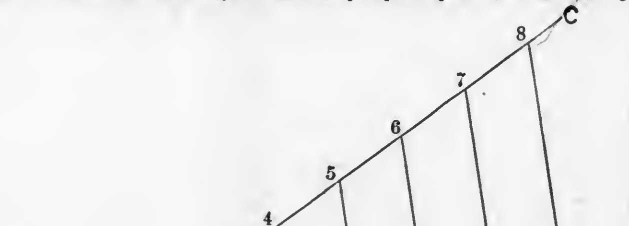


Fig. 30.

Fourth Method.—$A\ B$, fig. 31, being the line, draw $C\ D$ of indefinite length parallel to it and at any convenient distance from $A\ B$. Then from C lay off on $C\ D$ with the dividers and of *any* suitable size the number of parts, C 1, 1 2, 2 3, etc.; in this case ten. Through C and A, the ends of $C\ D$ and $A\ B$, draw a line, $C\ A$, and extend it to E. Then through D, the last division on $C\ D$ and B, the end of $A\ B$, draw the line $D\ B\ E$ so that it crosses or intersects $C\ A\ E$ at E. Now from the points of division 1, 2, 3, etc., on $C\ D$ and the point of intersection E draw lines 1 E, 2 E, 3 E, etc. These lines where they cross $A\ B$ at 1′, 2′, 3′, etc., will divide it into ten equal parts.

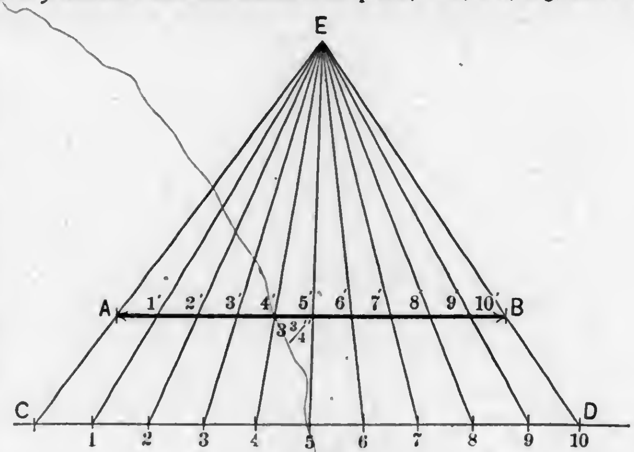


Fig. 31.

PROBLEM 7. *To divide a straight line proportionally to the divisions of another straight line.*

If $A\ B$, fig. 32, is a line to be divided in the proportion of $\frac{7}{15}$ to $\frac{8}{15}$, draw $C\ D$ of indefinite length and parallel to $A\ B$ at a convenient distance from it. Divide $C\ D$ into 15 divisions of any size. Draw $C\ A\ E$ and $D\ B\ E$ as in the preceding problem, intersecting each other at E. Then through the seventh division on $C\ D$ draw 7 E, and where it crosses or intersects $A\ B$ at F it will divide $A\ B$ in the proportion of $\frac{7}{15}$ to $\frac{8}{15}$.

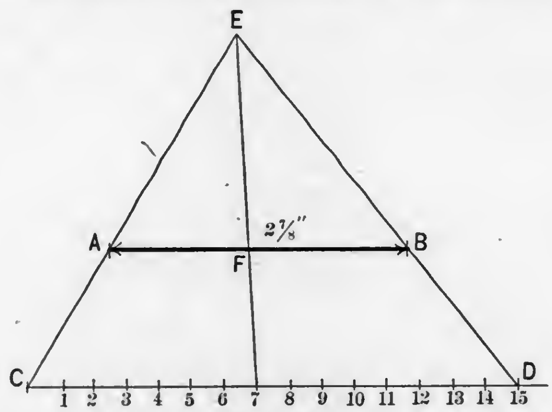


Fig. 32.

This problem can also be solved by the method illustrated by fig. 29 and 30, and it has a practical application in proportioning the teeth of wheels, as will be explained hereafter, and in other mechanical construction.

PROBLEM 8. *To draw a perpendicular to a straight line through a given point.*

First Method.—If the line is a horizontal one the perpendicular can be drawn easiest by placing a triangle, $A\ B$ or C, fig. 21, above the upper edge of the T-square and sliding it along so that its edge will intersect the required point. The perpendicular can then be drawn along the edge of the triangle. In doing this the blade of the T-square should be placed slightly below the line, so that the perpendicular may intersect it or be drawn so that the two lines will meet each other. If the line is a vertical one, a perpendicular may be drawn to it with the T-square.

Second Method.—If a line, $A\ B$, fig. 33, has been drawn along the long side of a 45 degree triangle E, in the position shown, then by holding the blade of the T-square or the straight-edge C securely in its place, and reversing the position of the triangle

as indicated by the dotted lines E', and drawing a line along the edge A' B', it will be perpendicular to A B.

If the line is drawn along the edge A B of the 30 and 60-degree triangle D in the position shown in fig. 34, then by re-

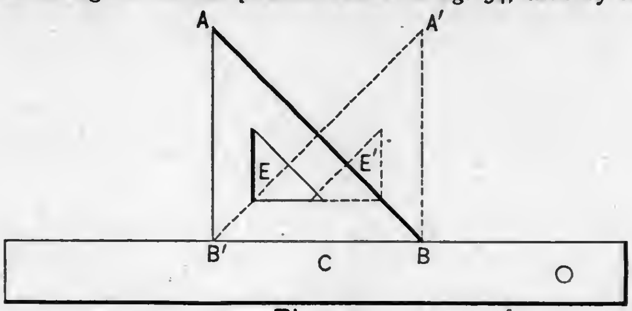


Fig. 33.

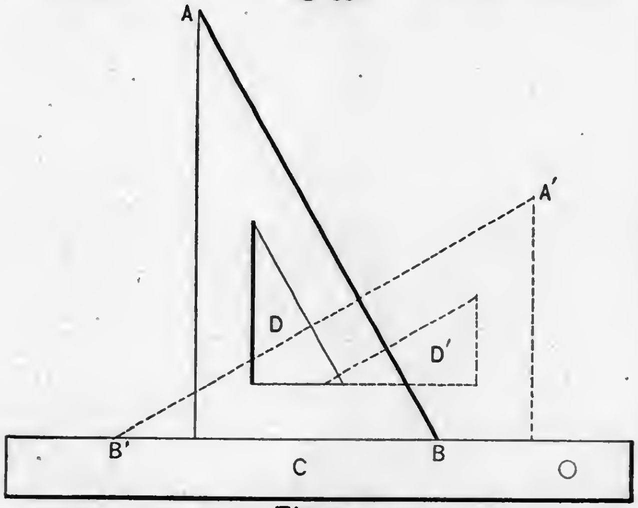


Fig. 34.

versing or turning it into the position shown by the dotted lines D' and drawing a line along A' B' it will be perpendicular to A B.

Third Method.—If the line A B, fig. 35, is inclined, and a is the point through which the perpendicular is to be drawn, then place a triangle, E, in the position shown by the dotted lines, and so that its edge C' D will coincide with the line A B, and hold it firmly in that position. Then place a straight-edge, C,

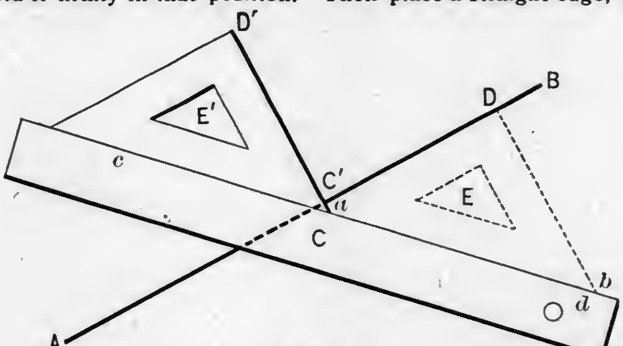


Fig. 35.

or another triangle so that its edge c d bears against the edge a b of E. Then hold C securely in its place and slide E along c d to the position shown by full lines at E', and its edge D' C' intersects the point a on A B. The perpendicular may then be drawn along the edge D' C' so as to pass through a. It will make very little difference whether the point through which the perpendicular is to be drawn is outside of the line A B, as, for example, at D', because in that event all that is required is to slide the triangle E until its edge intersects the required point.

A little practice in drawing perpendicular lines with triangles will teach the student more of the method of using them than he will learn from any description.

Fourth Method.—If the point C, fig. 36, through which the perpendicular is to be drawn is on the proposed line A B, and near its middle, draw from C as a center with any convenient radius, as C a, two short arcs, a and b, crossing A B. Then with a and b, the points of intersection of these arcs with A B, as centres, and with a radius, a C', greater than C a describe* arcs 1 1 and 2 2 intersecting each other at C'. A line C C drawn through C' and C will be perpendicular to A B.

Fifth Method.—If the point C', fig 36, through which the perpendicular is to be drawn, is not on the straight line A B—

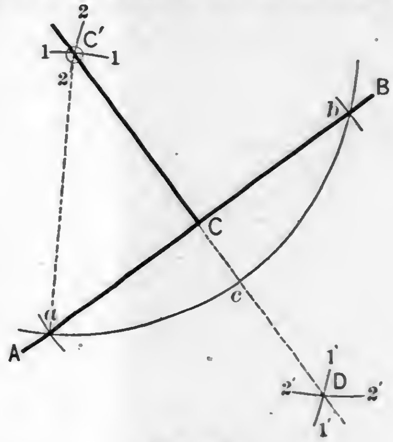


Fig. 36.

then with a radius, C' a, somewhat greater than the distance C' C of C' from A B, draw an arc, a c b, intersecting A B at a and b. Then with a and b, the points where a c b crosses A B, as centres, draw arcs 1' 1' and 2' 2' crossing each other at D. A line, C' D, drawn through C' and D, the point of intersection of 1' 1' and 2' 2' will be perpendicular to A B.

Sixth Method.—If a point is at or near the end of a line and it is horizontal or vertical, a perpendicular can be most conveniently drawn to it through the given point with a

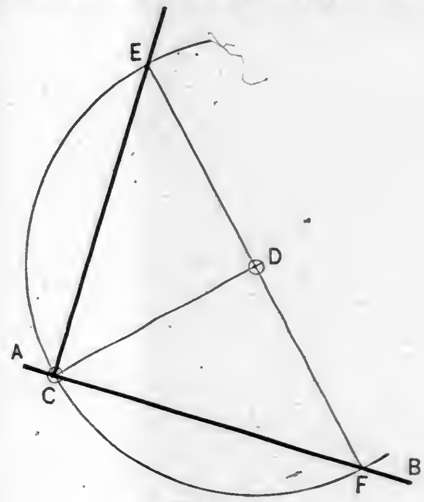


Fig. 37.

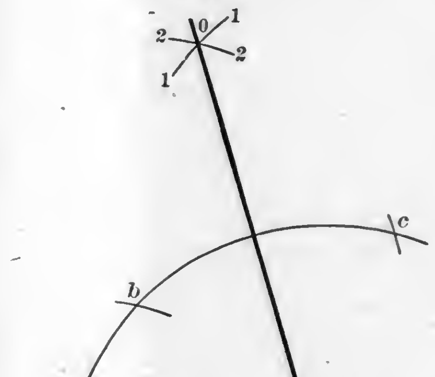


Fig. 38.

T-square and triangle in the manner explained in the last chapter. If the line is inclined, as in figs. 37, 38 and 39, it can

* To *describe* an arc means to draw it.

be done with two triangles in a similar manner to that described in the third method of solving Problem 8, and illustrated by fig. 35.

Seventh Method.—A perpendicular can be drawn through a point, *C*, fig. 37, at or near the end of a line, *A B*, with compasses as fol'ows: Take any point, *D*, above *A B* as a center, and with *D C* as a radius draw the arc *E C F*, cutting *A B* at

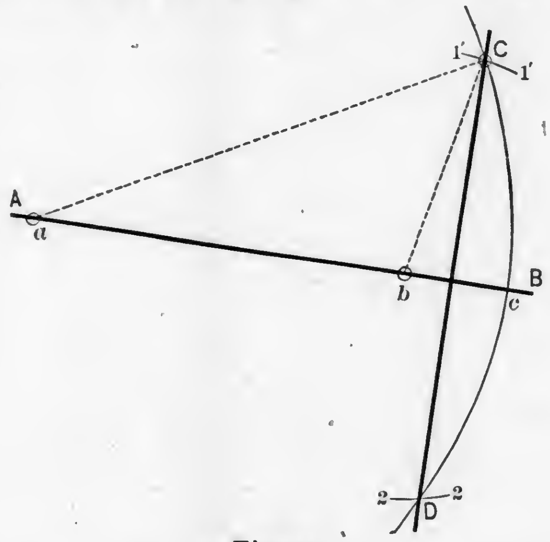


Fig. 39.

C and *F*. Draw the line *F D* through *F* and *D* and extend it so that it will cut *E A F* at *E*. From *E* draw the line *E C* through the point *C* and it will be perpendicular to *A B*.

Eighth Method.—From the point *C*, fig. 38, in the line *A B*, with any radius draw the arc *a b c*. With the same radius lay off from *a* as a center the distance *a b*, and from *b* the distance *b c*. With the same or any other radius and from *b* and *c* as centers draw arcs 1 1 and 2 2 crossing each other at *O*. Through *O* draw the line *O C*, which will be perpendicular to *A B*.

Ninth Method.—If the point *C*, fig. 39, is nearly over the end of the line *A B*, from any point, *a*, in the straight line *A B* as a center, and a radius, *a C*, describe an arc, *C c D*, passing through *C*. From any other point, *b*, in *A B* as a center, and *b C* as a radius, describe a short arc, 1' 1', passing through *C* and another, 2 2, cutting *C c D*. Draw the straight line *C D* through *C* and *D*, and it will be perpendicular to *A B*.

(TO BE CONTINUED.)

The Morton Valve Gear.

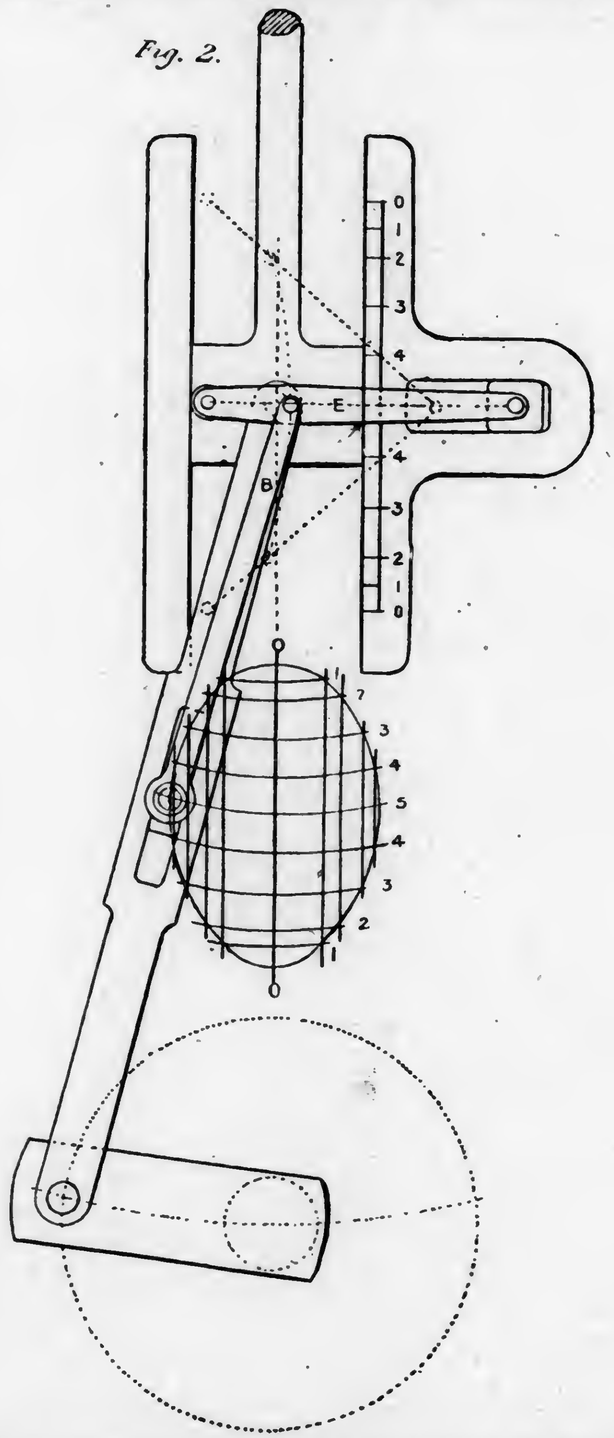
THE accompanying illustrations show the Morton valve gear, which is a radial gear worked from the cross-head, and which, it is claimed, possesses certain advantages over any previous form of the same gear. As will be seen, this system in reversing valve gear is of a type having many forms, the earliest one known being that invented and patented in England by Matthew Punshon, 1839, the best-known forms following that of Punshon being those of Engemann, Brown and Joy. In none of these earlier arrangements was provision made for correcting the irregular lateral vibration of that point on the connecting-rod which was the source of the valve's motion, this irregular lateral vibration arising from the angular movement of the connecting-rod. Hence it followed that in all the earlier forms of this class of valve gear it was impossible to obtain uniformity of motion between the valve and the piston.

It is well known that a fixed point *A* on the connecting-rod of a steam-engine will, on the revolution of the crank, describe a figure having the contour of an egg, the smaller end being nearest the cross-head; consequently the lateral vibrations of that point will be irregular. Fig. 2 shows one of the methods adopted by Mr. Morton to convert this irregular movement into a regular one, and a modification of this plan has been generally applied to the marine and locomotive engines to which Morton's system of valve gear has been fitted.

Confining the description to fig. 2, it will be observed that the point *A* is connected to the piston-rod cross-head through the link *B* and lever *E*; consequently *A* becomes a movable point or center in contradistinction to a fixed point, and on the rotation of the crank the movement of the point *A*, actuated by the piston, is so controlled that the figure described by it becomes a regular oval figure, having a major axis equal in length to the actual travel of the movable point. The ordinates, 1, 2, 3, 4, 4, 3, 2, 1, may be described crossing the figure with a radius equal to the length of the link *B*, and are equal in length at either end of the figure for every corresponding increment of the piston's travel from either end of its stroke, as indicated by the figures 1, 2, 3, 4, 4, 3, 2, 1, on the cross-head slide-bar.

Fig. 3 shows how in single-crank engines the point *A* may be actuated from a return crank fixed on the main crank-pin of the engine, through the link *B*.

Here is a simple means whereby the distorted motion inherent in previous forms of connecting-rod valve gear is converted into a regular motion. Fig. 4 shows by what means this cor-



rected connecting-rod motion may be conveyed to the fulcrum center *G* of the radial lever *F*. Instead of the movable point sliding on the center-line of the connecting-rod, it becomes the center *A* of a radiating spanner or crank *P*, centered in a projection *P'* on the connecting-rod, and actuated from the piston, as described in fig. 2, the point *A* radiating equally across the center line of the connecting-rod instead of sliding upon it. Now on revolving the crank the movable point *A* will follow an oval path similar to that described in the preceding figure, but the major axis of the figure will have become a segment of a circle, having a radius equal to the length of the lever *F*, which is attached at *G* to the link *C*, vibrating from the fixed center *K*.

On revolving the crank of the engine it will be seen that for every movement of the piston from either end of its stroke the center *G* has a corresponding movement to that of the piston, and equal on either side of its central position, which is on a line drawn parallel to the center line of the engine, and coinciding with the position of the vibrating link *C*, when the engine is at either end of its stroke. It will be seen that a line drawn through the crosses which may be made by a pencil point at *C* in lever *F* (see fig. 4), in one revolution of the engine would be as the arc of a circle having a radius equal to the link *B*. It should here be stated that if the amount of relative travel imparted to the movable point *A* be either more or less than that required to obtain the true geometrical oval path thereof, a line drawn through the crosses, which would then be made by a pencil point at *G*, would form a curve partaking of the nature of an angled ogee line, as *a b*, when the travel is too little, and as *c d*, when the travel is too great, the mathematically correct amount of relative travel in the point *A* producing the crosses on a true curve, *e f*, as shown in fig. 4 and fig. 5. The lever *F* may be prolonged beyond the point *A*, and connected to the cross-head of the piston-rod by the link *B* at the point *D*.

Other arrangements might be shown by means of slight modifications, which will readily suggest themselves to any one familiar with the subject, but it is believed that the illustrations given will be sufficient to show the general principles of this gear and the advantages offered by this device.

The gear has been fitted to an outside-cylinder locomotive by an arrangement which will be easily understood. One of the advantages claimed for it in a locomotive is that the whole motion is outside of the engine, and easily reached for oiling and repairs. The return-crank method, shown in fig. 3, is used in this case.

This gear has been at work in England for some years with favorable results. It has been adopted on the Inman Line Steamer *Ohio*, and by several other steamship companies. It is in use on the North London Steam Tramway and on some locomotives on the North British Railway. On a triple-expansion marine engine it is claimed that at least 10 per cent. is saved in space and cost. Mr. Robert Bruce, of 70 Bishopsgate Street Within, London, is Engineer in charge of this invention.

Fig 3.

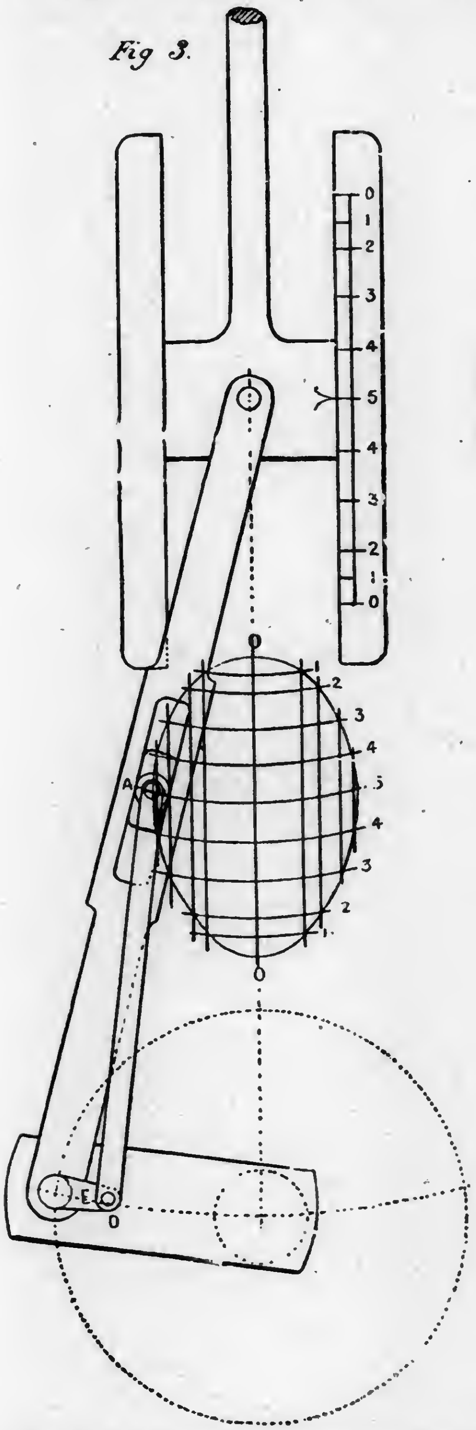


Fig. 4.

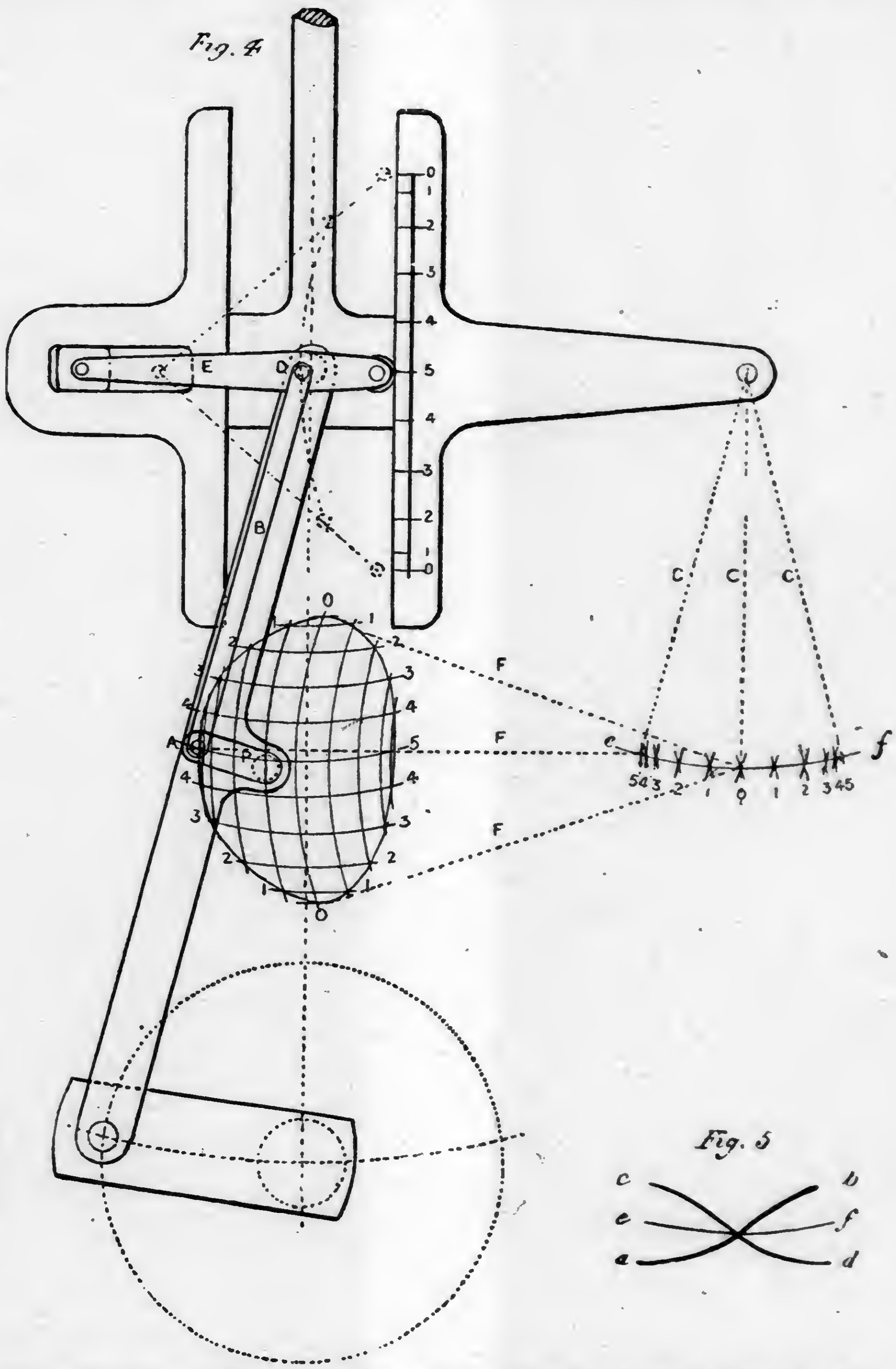


Fig. 5.

Recent Patents.

I.—MALLEABLE IRON GEAR-WHEELS.

THE accompanying illustrations show a new form of malleable iron gear-wheel, which has been devised to meet the objec-

tions generally made to malleable iron gears, which are that certain parts being thicker than others they cannot be thoroughly annealed, and also that a malleable casting shrinks more in cooling than any ordinary casting. In the illustrations fig. 1 is a perspective view of the ordinary spur gear-wheel; fig. 2 a gear-wheel with flange for bolting to the arms of a larger wheel, and fig. 3 is a half view of the bevel gear showing one form of arms adopted.

Fig. 1.

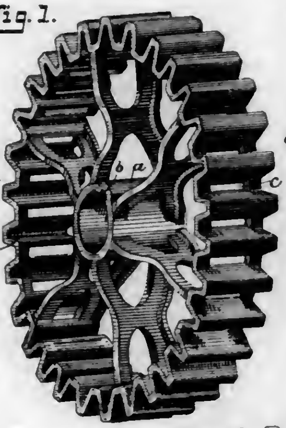
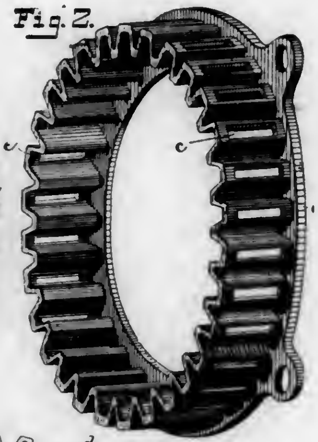


Fig. 2.



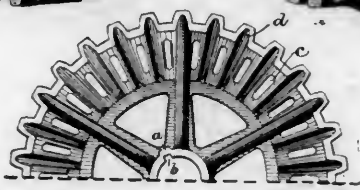


Fig. 3.

The hub is formed of an equal thickness of metal on all sides, the ridge *a* being formed for the keyway *b*. The arms may be designed, as in fig. 1 or in fig. 3. The teeth are recessed at the back, as shown at *d d*, giving them something of a **U**-shaped section, and forming of the teeth and rim a continuous corrugated band of metal, the section providing also for shrinkage. In the rim of the wheel are formed openings *c c*, between the teeth, through which dirt, straw, or other clogging matter may freely pass. The openings may be made in any form desired.

This method of casting gear-wheels is covered by patent No. 415,755, which was granted to William N. Whiteley, of Springfield, O., under date of November 26, 1889.

II.—PROCESS OF BUILDING TUNNELS.

Patent No. 417,288, issued under date of December 17, 1889, to Charles Sooysmith and Edward L. Abbott, of New York, is for a Process of Building Tunnels and Shafts. This is described in the specifications, as follows, and is shown in fig. 4:

"Our invention relates to the process of excavating in earth, mud, or the like, wherein the part to be excavated is frozen to solidify it before being dug.

"The object of our invention is to so improve the process of excavating that it may be performed more easily and with greater speed than has hitherto been done.

"Before our present invention the idea of solidifying the inner surface of excavated tunnels by cold air for the purpose

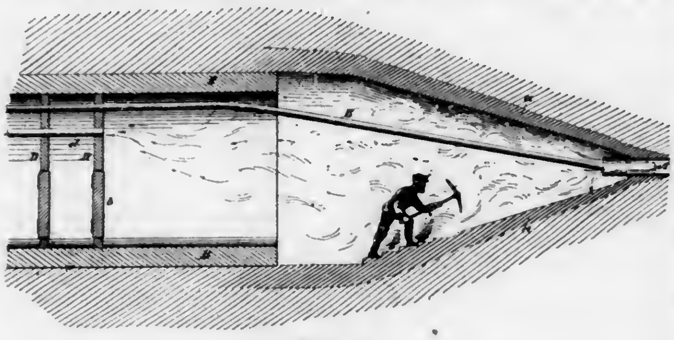


Fig. 4.

of hardening the part to be dug had already been carried out; but in that case the surface or wall at the inner end of the excavation was practically flat, or the wall left vertical.

"In carrying out our invention the excavation is kept in the form of a cone or pyramid, with the apex in the direction in which the excavation is being made. In order to freeze or solidify the earth to be excavated, we place a pipe or chamber *A* at the apex of the excavated cone, as shown in fig. 4. This pipe or chamber is supplied with cold air or other freezing-fluid by means of a pipe *B*, that is connected with a suitable source from whence the freezing-fluid may be supplied to the pipe *A*. The cold air or other freezing-fluid, being passed to the pipe *A*, freezes the earth in the vicinity of said pipe, and then passes from the pipe *A* back through the excavation, as indicated by the arrows in the drawing. If any other fluid than air is used, it is necessary to conduct it away in a separate pipe. This cold air freezes or solidifies the earth composing the inner wall of the cone to a certain depth, as indicated by the heavy section lines *a* in the drawing. The worker now removes partially the frozen layer of earth in the excavation, always keeping the excavation in the shape of a cone. As the work is going on and a layer is removed, the earth thereby left exposed is continuously kept frozen, and this freezing and removing of the earth layer by layer is kept up continuously until the desired diameter at the base of the cone is produced, whereupon a lining *B* is made in the excavation or tunnel, which is extended in a forward direction whenever the base of the cone has reached the desired diameter. As the earth at the apex of the cone is frozen and dug away, the pipe *A* is gradually advanced into the earth, the freezing of the earth about the pipe taking place each time the pipe is advanced, while the remainder of the excavation is being removed layer by layer until the desired diameter is reached. By this means we are enabled to remove within the same time a larger amount of earth than heretofore, because the part to be excavated, instead of being a mere flat wall against which the workmen operate, is a long inclined surface upon which the operators can work, and thereby the work of freezing and excavating can progress more rapidly, the workmen taking care not to remove the earth beyond the limit of frozen material. This ability to speedily excavate is due to the fact that the extent to which earth is frozen in a certain direction is not in direct proportion to the degree of cold applied to a point, but is more nearly in proportion to the area exposed to the cold.

"In order to keep the cold air in the part of the tunnel or shaft that is being excavated, we place one or more partitions *D* in or near the finished part of the tunnel or shaft, which prevent the sudden outflow of the cold air. These partitions may be provided with doors *b* for the admission and egress of workmen, implements, and the like. A comparatively small tube *d*, or other opening, may extend from the partition *D* to carry back the returning air.

"In practice the freezing will be kept up at the same time as the excavation and lining are taking place, making the process continuous. Care should be taken in removing the thin layers of frozen material not to approach too near the unfrozen material.

"The air in the heading or freezing pipe or chamber *A* may be cooled by ordinary refrigerating apparatus in any convenient way, either by the cold-air machine, in which case the air will come directly from the machine, or by air cooled by contact with coils containing cold fluid, or by placing within the freezing chamber or pipe *A* coils or tanks through which a cold fluid is passed.

"The apparatus shown in United States Letters Patent No. 340,161, dated April 20, 1886, might be used to advantage in carrying out our improved process.

"From the above description it is seen that only one freezing-pipe or chamber or bunch of freezing-pipes is used, the earth being excavated around said pipe or bunch, instead of placing a series of pipes in a circle and excavating the material left between said pipes.

"It is evident that instead of making the walls of the excavation in the shape of a cone, the excavation could be left with parallel walls, and if the earth at the side of the freezing-chamber were not frozen to the desired diameter, after the frozen material was removed the cold air could be let into the excavated part to freeze the side thereof, similarly to the use shown with a cone or conical form. This process may be repeated until the desired diameter is obtained."

Red Rock Bridge.

On March 25 last the west half of the Red Rock Cantilever Bridge was completed. It will be remembered that this is the Atlantic & Pacific Railroad crossing of the Colorado River, a few miles below the dining station at the Needles, Cal.

This bridge is a through cantilever with a span of 660 ft. center to center of main pins. The shore and river arms are 165 ft. center to center, respectively, and the suspended span has a length center to center of 330 ft., giving a total length of 990 ft. When completed this bridge will supersede the Tyrone Cantilever as the longest cantilever span in this country,

and no doubt will in its turn in a few months be surpassed by the Memphis Bridge.

The erection is being accomplished with but one traveler, and in consequence but one-half of the bridge can be built at a time. On March 25 the tearing down of the traveler commenced; it was transferred to the east side of the river, and the second half of the bridge is now being rapidly erected.

The date for completion has been set at May 1, and every effort is being made to finish the work if anything before this date, as about ten miles of track now being used by the railroad is in ever increasing danger of being washed away by high water and the traffic of the road stopped.

We hope to be able to give a more detailed account of the structure and of the method of adjustment of the suspended span after the bridge has been completed.

Manufactures.

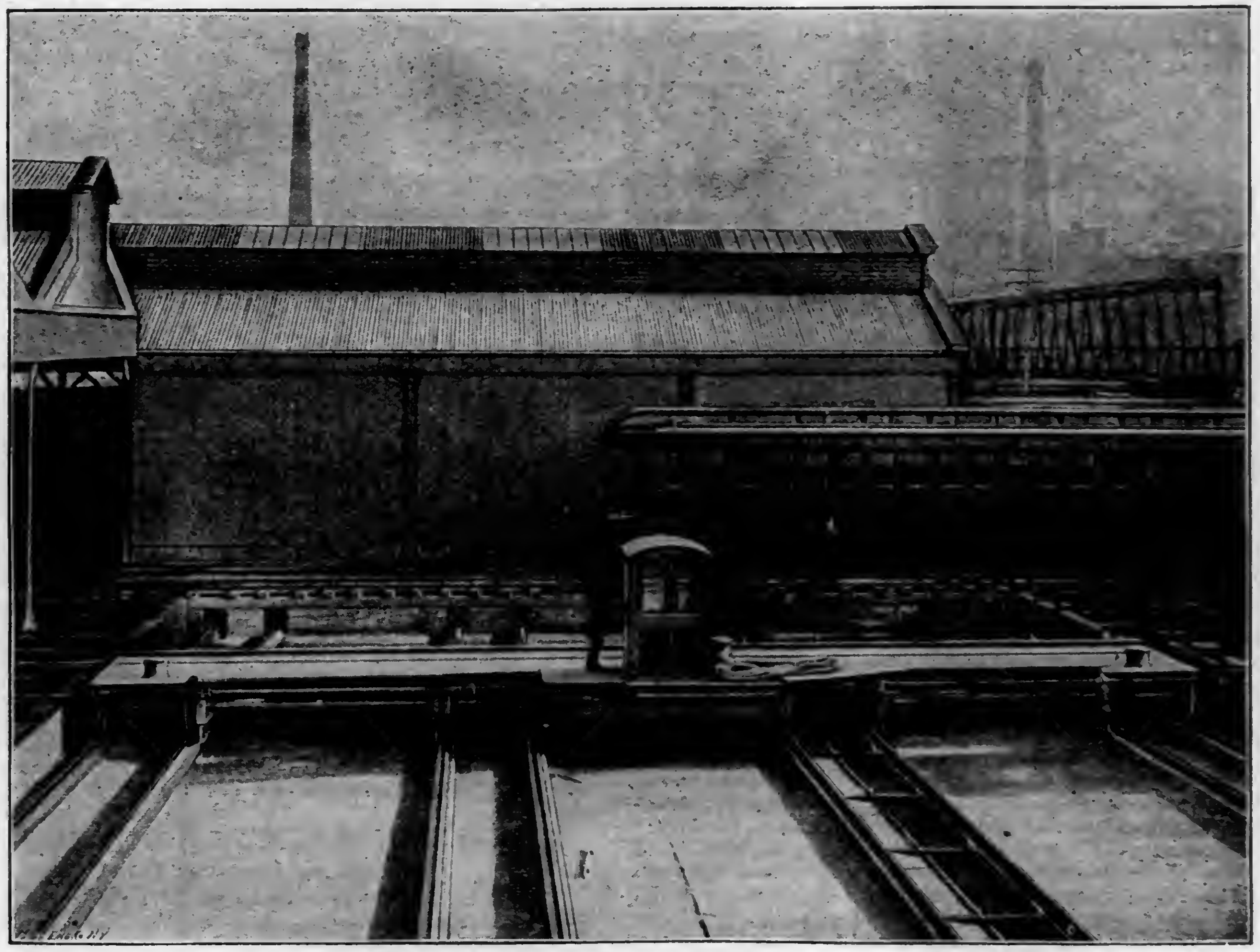
Electric Transfer-Table, New York Central & Hudson River Railroad.

THE accompanying illustration shows an electric transfer-able, recently installed by the Sprague Electric Railway & table, installed by the Sprague Company for the Wisconsin Central Railroad, there is an overhead contact. The current used is only 220 volts, and hence, while not wholly pleasant to take in one's body, it is in no way dangerous. The current is taken from the same dynamo that furnishes light for the station. The full current capacity of the table motor is 60 ampères.

The speed of the electric motor is governed by a switch which throws the winding of the field into different combinations, thus altering the current, maintaining a practically constant strength of field without the use of any wasteful resistance. The control over the speed of the motor is perfect, and no complicated nest of gearing for changing speed is required.

The motor is supported at one end, according to the regular Sprague method, by double compression springs playing upon a bolt which rests upon the platform of the transfer-table. This method has been developed in street railroad work and other places where it is desirable to start slowly under a heavy load, and has proved very satisfactory. At the other end the motor is sleeved on a rigid support. By means of this flexible attachment all danger of stripping the gears is eliminated, and the strain upon the gears is always a progressive one.

The advantages of electric power for this work are claimed to be great. The equipment is very much lighter than if steam-power were used, and there is no expense of operation when the table is not in use. One man can easily handle the table, and more conveniently and directly than with steam.



ELECTRIC TRANSFER TABLE, GRAND CENTRAL DEPOT, NEW YORK.

Motor Company for the New York Central & Hudson River Railroad.

This table differs from the earlier ones chiefly in the electric motor, which is of 15 H.P. instead of $7\frac{1}{2}$ H.P., and also in the contact arrangement. The contact is obtained from a couple of heavy copper wires stretched taut about 3 ft. apart over the second of the four parallel tracks, the wire being carried on insulators fixed to light cast-iron cross-beams, so as to be a few inches above the rails. The conductors are kept taut under all changes of temperature by springs at one end. Over these wires two contact rollers travel beneath the table, being kept in contact by gravity only. In the Altoona electric transfer-table, installed by the Sprague Company, there is an outer contact maintained by springs, while at the Waukesha transfer-

The two end capstans shown on the table are fixed; the center one is revolved in either direction by a simple clutch-gear. It is used, of course, for working cars on or off the table without locomotive power.

The capacity of the table is 100,000 lbs. Ordinary car axles, bearings, and wheels are used throughout for the running-gear, and the total cost of the table and motor complete was under $7,000. Its speed is about 150 ft. per minute, the same as the old wire-rope table which it replaced. The old pit was lengthened somewhat, and accommodates 10 tracks. The rails are carried on wooden longitudinals resting on small masonry foundation walls. The pit drains directly into the city sewers.

The table is constructed with 15-in. cross-beams and 12-in. longitudinals, thoroughly braced with a rigid lateral system. It

was designed and built by the Yale & Towne Manufacturing Company, of Stamford, Conn.

The small cabin, shown at the center of the table, is provided for the operator.

Electric transfer-tables have now been adopted by the Pennsylvania, the Philadelphia & Reading, the Chicago, Burlington & Quincy, the Wisconsin Central, and other prominent railroads, and they are now recognized as an essential feature of an extensive and well-equipped railroad yard.

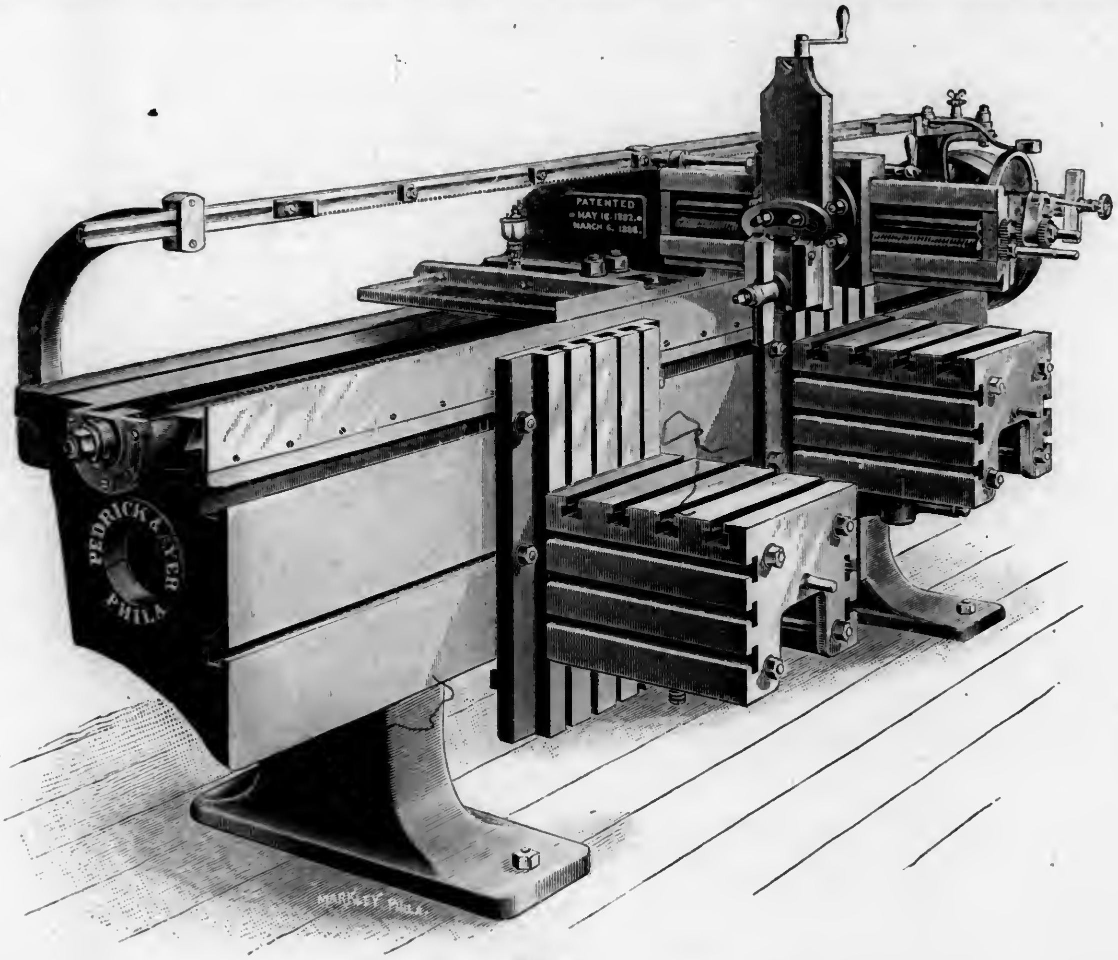


Fig. 1.

THE RICHARDS OPEN-SIDE PLANER.

Steam-Engine Foundations in the Air.

AMONG the remarkable examples of bold engineering in the great sugar refinery of Claus Spreckels, at Philadelphia, one of the most unique is the hanging or aerial steam-engine foundations. The engines used in this establishment are distributed practically all over the buildings, a large proportion of them being on upper floors. Some of these engines are bolted to iron beams or girders on second and third stories of the building, and are consequently innocent of all foundation. Some of these engines ran noiselessly and satisfactorily, while others produced more or less vibration and rattle. To correct the latter, the engineers simply suspended foundations from the bottoms of the engines, so that, in looking at them from the lower floors, they were literally hanging in the air. It would seem from this result that a foundation does service to an engine, or any machinery by its weight alone, no matter what is under it; a somewhat unexpected result.

Electric Welding in the Navy.

THE special board appointed by the Secretary of the Navy to investigate the Thomson electric welding process finds that this process will be very useful in making repairs on ship-board and for many other purposes. The report says:

"It is the unanimous opinion of the Board that in the present day of ships constructed almost entirely of metals, and in which every fitting possible is made of metal, such a system as that which has been investigated by us becomes not only desirable, but a means to economy of expense, time and labor, and would add to the efficiency of the vessel under any condition of service.

"This system of welding occupies a position of its own; it is able to do not only a large part of the work of the forge now in use, but is capable of doing much work that was hitherto considered impracticable. By its use, the large accumulation of now almost worthless boiler tubes stored at the navy-yards could be made fit for service, and the quantity of spare tubes and of many other stores now carried by ships could be reduced.

"As the classes of work at naval stations and on ship-board differ materially, the welders designed for use in the two places should be constructed for the work that will be required of them; those for use on board ship being especially designed with a view to lightness, compactness and adaptability to general work."

The Richards Open-side Planer.

THE accompanying illustrations show the Richards patent open-side planer, a machine tool which can be used as well as an ordinary planer on ordinary work, and is also capable of a great range of work on special and difficult jobs. Its general construction and arrangement will be readily seen from the engravings.

This planer is built in different sizes, the one shown in the cut having a bed 10 ft. 6 in. long; this size machine will plane 8 ft. in length, 25 in. in width and 24 in. in height when using the square table.

Pieces 42 in. high will clear the arm when setting on the floor, and if the machine is located over a pit its capacity for difficult work is increased, and by taking advantage of the open side, pieces of unusual dimensions may be planed with comparative ease.

The screw running the entire length of the bed is driven by high-speed pulleys and shifting belts without the use of gearing, and imparts a smooth and quiet movement to the traveling carriage and arm that supports the swivel head and cutting tool.

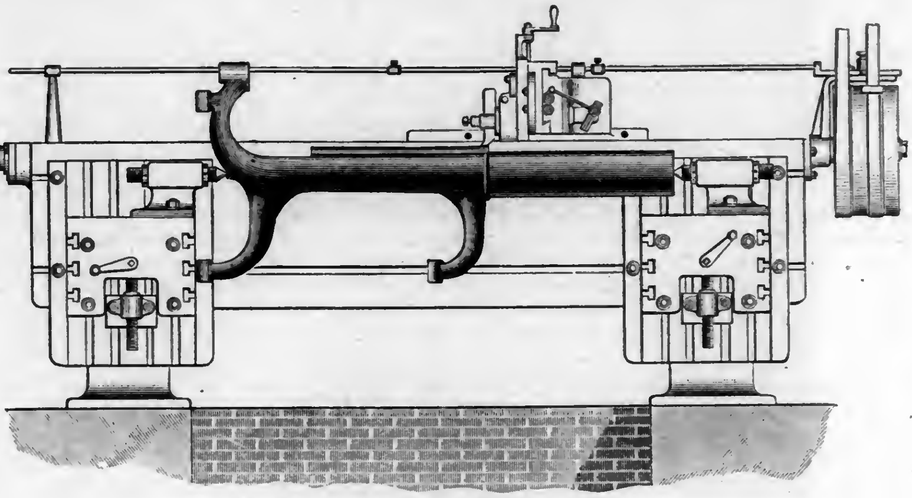


Fig. 2.

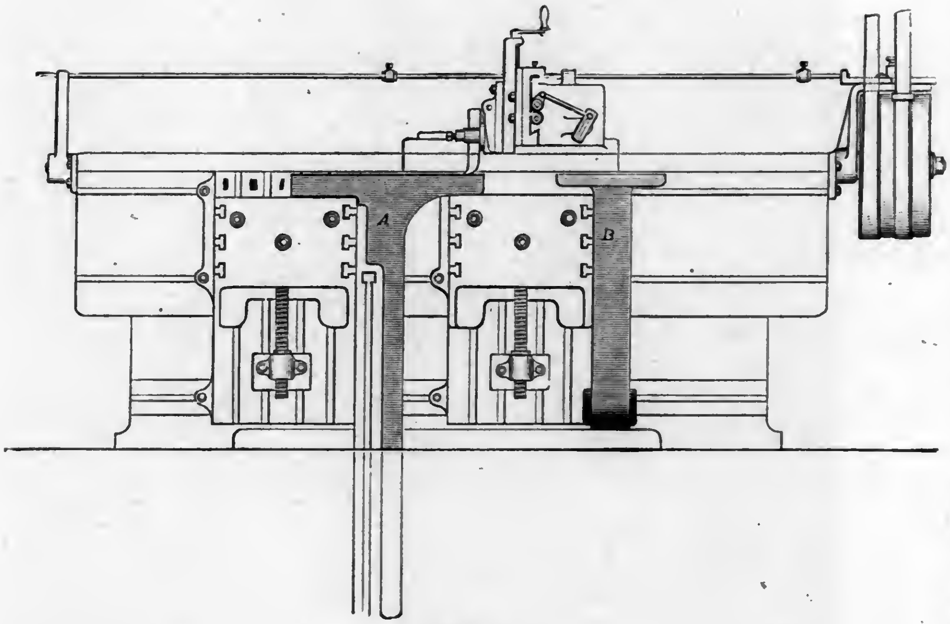


Fig. 3.

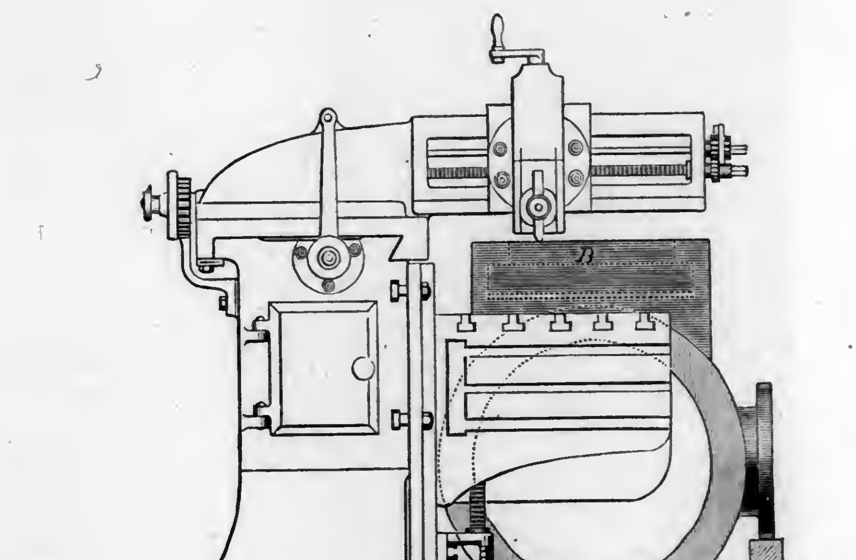


Fig. 4.

This overhanging arm is so proportioned and constructed as to ensure the requisite stiffness when used at its outer end, and is cast with or firmly bolted to the carriage or saddle, which is well gibbed to the bed of the machine.

The shifting of the belts is accomplished and the movement of the saddle reversed by means of adjustable tappets on the belt-lifting rod above the screw, and the proper speed forward and the quick return or backward movement is governed by the relative diameters of the pulleys upon the countershaft.

The slotted plates and square tables can be set in any position along the bed, or removed entirely when planing heavy frames and castings that require more room in setting, and could not well be done at all except on large and costly machines.

The movement of the cutting tool being parallel with the bed and extending over both tables in the same direction, one of the tables may be set to take the tool thrust at the proper height, saving time in the setting and fastening of work, as well as providing a solid and convenient stop.

Pieces may be planed on one of the tables while fastening work upon the other, and when used in this way will fill the place of two machines.

The arrangement of the slotted plates and tables will admit of many changes in the way of fastening work, but whenever a continuous support is needed, or the space between the tables not required, an extra plate or filling piece is bolted between them, making one continuous bed or table of the length required.

The length of the stroke permits the use of the table at different points along the bed, and prevents the undue wear that might take place if used for a long time in one position.

Some of the advantages claimed for a movable cutting tool are, that the weight and friction of the sliding carriage or saddle is the same at all times, and does not increase with the weight of the work or length of machine bed. The work remains stationary and may be conveniently and securely fastened to the slotted plates or tables, so that the cutting tool, when planing large or heavy work, may operate at the same height or level as when used upon the medium and smaller pieces.

Two out of the many possible applications of this machine have been selected for illustration here. Fig. 2 shows the machine in position for planing the sides of a boring machine table *A*. This kind of work, as may be seen, is done at the same expense and convenience as though it were a flat plate. The table *A* can be of any length, and project downward into a pit, as shown by the dotted lines. As the work does not move, the operation is like any common planing, takes only one-half the usual time, and is done in a superior manner.

On the other table is shown a long bracket, *B*, mounted for planing. In this case, it may be observed, there is no change or adjustment of the machine required. The vertical surface for fastening is provided, so no angle-plate is wanted. The work can be fixed in a few minutes, and the cutting is done in a convenient plane.

Fig. 3 shows the machine doing several kinds of work, all of which could be *fastened at one time* if desired.

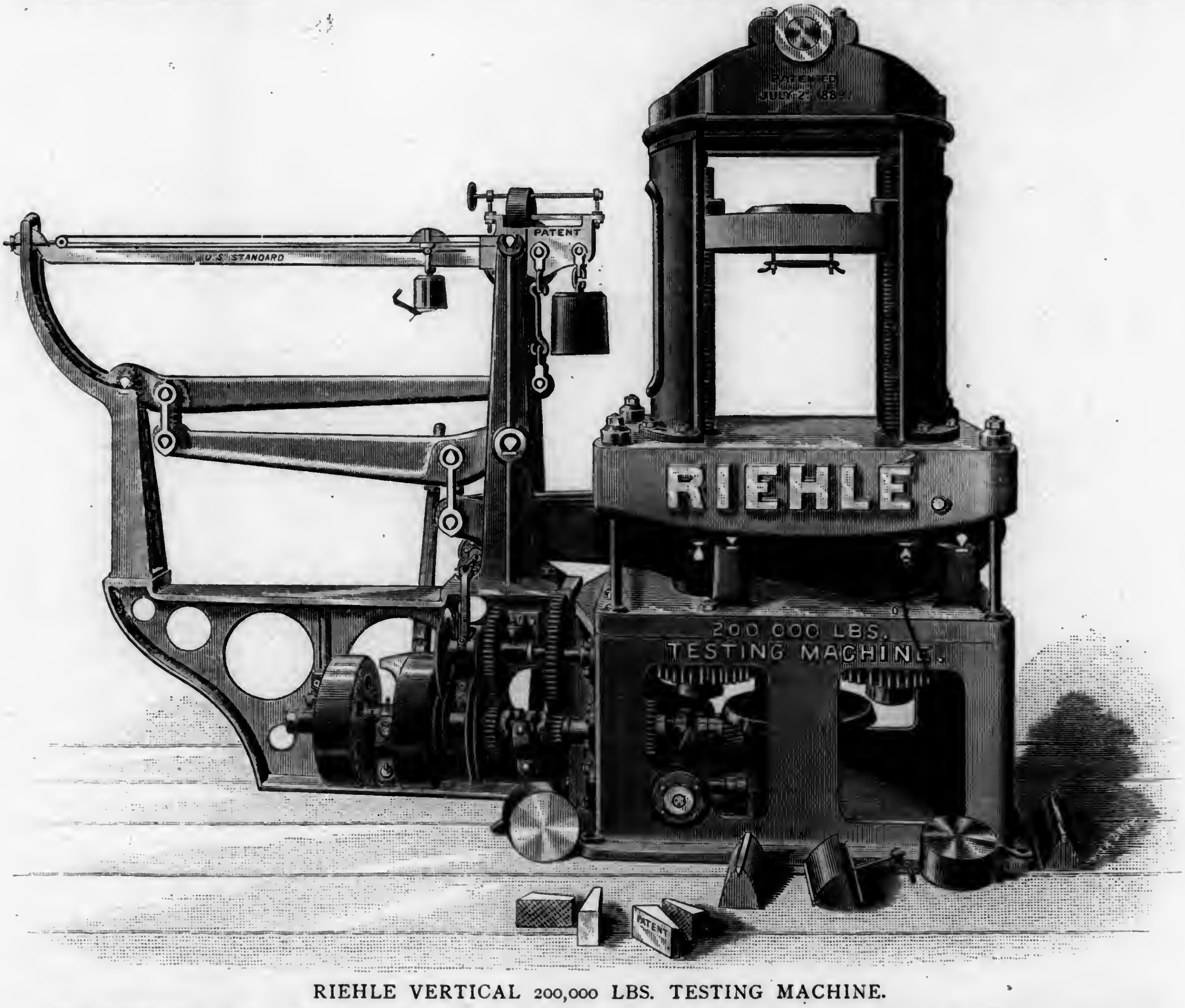
At *A* is a pipe flange being planed, the other end, of any length, extending into a pit, shown by dotted lines.

At *B* the foot of a diagonal brace is being planed, and at *G* the foot of a stand or column, which could be of any length.

Fig. 4 shows the machine planing the valve seat of a steam-engine cylinder *B*.

All the planing required for a steam-engine of 20-in. bore has been done on a machine of this kind. For some of the work the machine has had to be raised by putting blocks beneath; but, on the whole, the work was well and cheaply done.

None of the work above can be done conveniently on a common planing machine, while here, as before remarked, it is the same as planing flat plates.



RIEHLE VERTICAL 200,000 LBS. TESTING MACHINE.

Did space permit, many other illustrations could be given, such as planing valve-seats of large cylinders; planing sections of pulleys; machine frames; milling machine columns and similar pieces; lathe-beds; and generally pieces of difficult and unusual shapes. In fact, it seems difficult to find a limit to the range of work possible.

A number of these planers are in use, giving much satisfaction. They are made by the well-known firm of Pedrick & Ayer, of Philadelphia.

A Large Testing Machine.

THE accompanying illustration shows a Riehle patent vertical screw-power testing machine of 200,000 lbs. capacity. It is a well-designed and substantial machine, and in it are combined the latest improvements as to speed, etc.; it is also furnished with appliances for testing specimens by tensile, transverse, and compression strains. The total weight of the machine is a little over 10,000 lbs., and it is about 11 ft. long, 8 ft. high, and 4 ft. wide.

For tensile strains specimens from 8 in. to 24 in. in the clear length and of 2 in. in diameter and less can be tested. For transverse strains specimens can be made from 24 in. down to 12 in. or less in length, and by special appliances almost any reasonable length can be tested. The compression tools are of steel and are 8 in. in diameter. The motion of the head is 30 in. The machine has two adjusting speeds and six different speeds by which a specimen can be stretched or broken; also for driving in opposite directions. The maximum speed for testing and light tests—80 revolutions of pulley—is $5\frac{1}{2}$ in. per minute. There are a number of adjustments that can be arranged on this machine.

Strains from 10 lbs. up to 200,000 lbs. can be weighed, and by the use of the patent vernier poise all the weights can be reduced on the beam, or any part, as may be preferred. Many varieties of special forms of material can be tested very accurately, even though subjected to a very great strain.

In this machine there is applied the Riehle patented high-faced wedged grip, by the use of which it is claimed that flat specimens of material, such as boiler plate, etc., can be tested and without any tendency to tear from the edge. The high-faced wedges engage themselves first through the axial line of the specimen and from that line out; it is also claimed that this machine is so carefully designed and constructed as to be well adapted for the combination of high strains and very delicate work required of it. Machines of this kind are in use at the Navy Yard in Boston and at the Midvale Steel Works, in both places doing excellent work; the tests upon them are accepted by the Government as standard.

This machine is built by the well known firm of Riehle Brothers, in Philadelphia, who are owners of the patents covering the various features of its construction.

Bridges.

THE contract for one mile of the elevated road in Sioux City, Ia., has been let to the King Iron Bridge & Manufacturing Company, of Cleveland, O., by the Sioux City Rapid Transit Company.

THE Atlantic Coast Line has let the contract for the Contentnea draw-bridge to the Edge Moor Bridge Works. This bridge is a 145-ft. plate girder draw-span.

THE Union Bridge Company has contracts for a number of bridges from the Queen & Crescent System and the Missouri, Kansas & Texas.

THE Passaic Rolling Mills Company has built a number of plate girder bridges for the New York & Northern this season, and has recently received the contract for a sheer through span 67 ft. long, to be erected near Aqueduct station on that road.

THE Union Bridge Company is pushing the work on the new eyebar plant. The building will be directly opposite the office at Athens and convenient to the present testing house and shipping-yard for eyebars. The eyebar plant from the Buffalo shops will be brought to Athens, and with their present plant there will be located in the new building. Both plants will be improved, and the combined output will probably much exceed the sum of the separate outputs hitherto. One of the features of the new plant will be the location of furnaces and an upsetting machine at each end of the building, thus avoiding the necessity of running the bars outside and turning them round. The combined plant will require considerable improvement, and the addition of a number of large dies, in order to manufacture the eyebars required for the Memphis Bridge, among which are bars 10 in. $\times 2\frac{1}{2}$ in. It is planned that the plant shall have the greatest capacity in the country, and shall be thoroughly equipped to manufacture the largest bars with the best attainable results.

THE Boston & Maine Railroad has let the contract for an iron bridge of three 123-ft. spans in East Boston to the Boston Bridge Works.

THE Springfield Improvement by the Boston and Albany Railroad is now practically complete. This has comprised two handsome depot buildings and the elevation of tracks and depression of Main Street to secure an overhead crossing.

THE Ohio & Mississippi Railroad has let the contract for the White River bridge to the Union Bridge Company. It will be manufactured at Buffalo, and comprises three 150-ft. spans.

THE erection of the Susquehanna Highway bridge, at Harrisburg, Pa., is progressing rapidly. The bridge comprises 12 spans of 175 ft. each, and two of 250 ft. each. Dean & Westbrook are the contractors, the shop work being sub-let to the Phœnix Iron Company.

THE Shiffler Bridge Company has been organized in Pittsburgh with J. W. Walker, President; F. L. Geist, Vice-President and Treasurer; Charles D. Marshall, Secretary. The new company takes the Shiffler Bridge Works, heretofore owned and operated by J. W. Walker.

THE Phœnix Iron Company has commenced to manufacture the iron and steel for the new Louisville bridge.

THE three bridges built by the Pencoyd Bridge Company to cross the Schuylkill River, about seven miles above Philadelphia, are rapidly approaching completion. All three are nominally for the Philadelphia & Reading Railroad, though that nearest Philadelphia is much more in the interest of the Baltimore & Ohio. This comprises one masonry and seven plate-girder spans. It practically joins the present West Falls Bridge at the Eastern end and curves South, thus avoiding the Y now used by the Baltimore & Ohio through trains. It is expected that trains may be run over it early in March. The next bridge is about one mile up the river, and has four deck-spans of lattice girders. It is a comparatively high bridge, and does not connect with the main line, but makes an overhead crossing. The third is just above the Pencoyd shops, and will connect the Norristown Branch of the Reading with the Pencoyd yards and the main line. It is a lattice girder bridge of four deck-spans.

THE contract for the proposed elevated road in Sioux City, Ia., has been let to the King Iron Bridge & Manufacturing Company, of Cleveland, O.

THE iron work for the bridge across the Ohio at Louisville is now in the shops of the Phœnix Bridge Company. Work on the foundations is rapidly approaching completion.

THE Lake Shore & Michigan Southern Railroad contemplates extensive bridge work during the coming season. Most of this will be necessitated by the double-tracking of the entire line, which has already been begun. Two contracts have been let to the Union Bridge Company, a 300-ft. draw-span at Cleveland and a bridge of three 150-ft. through spans at Grand Rapids. Both are being built by the Buffalo shops, with the exception of the drum and track circle for the draw-span, which are being built by the Athens shop.

Manufacturing Notes.

THE Strong Locomotive Works are to be built between Sharon and Glendale, near Cincinnati, where the Company has purchased a track of 1,350 acres of land, on which it will build not only the works themselves, but houses for the men employed, the purpose being to establish a town somewhat after the manner of Coleman. The works will be very extensive, and will have a capacity of one locomotive per day. It is proposed to build not only the Strong locomotive, but others of ordinary pattern, as may be ordered.

THE Dunham Manufacturing Company, Chicago, together with the National Hollow Brake Beam Company, removed April 1 to their new and commodious quarters, 703–707 Phœnix Building. This change has been made necessary in order to accommodate their rapidly-increasing business, and the new location will give them about double the space now occupied in the previous offices in addition to affording superior light and ventilation.

THE shops of Pedrick & Ayer, in Philadelphia, are being enlarged by the addition of two stories, the full size of the building, about 60 $\times$ 100 ft. This will nearly double their capacity, and has been made necessary by the increase of business, although the firm only moved into the present building a year ago.

THE new steel boat for the New York Fire Department built by the Jonson Foundry & Machine Company, New York, was launched April 5. The *New Yorker*, as she is called, is 125 ft. 5 in. long, 26 ft. beam, and has a displacement of 350 tons. Her machinery consists of a triple expansion engine, built by Brown & Miller, of the Vulcan Engine & Boiler Works, Jersey City, with cylinders 15 in., 24 in. and 39 in. in diameter and 24 in. stroke. Her motive power will be generated by two steel boilers of the Scotch type 12 ft. in diameter and 13 ft. long, which are now building by McNeill & McLaughlin, of the Franklin Boiler Works, Greenpoint, L. I. These boilers will be supplied with four 38-in. patent corrugated furnaces, made by the Continental Iron Works, of Brooklyn. Her propeller consists of a four-bladed sectional wheel supplemented with a Kunstadter patent swiveling wheel, which is fitted to the main shaft abaft the rudder. Her four sets of fire pumps, of special pattern, are being built, two sets by Clapp & Jones, of Hudson, N. Y., and two sets by the La France Engine Company, of Elmira, N. Y.

OBITUARY.

WILLIAM GALLOWAY, the oldest locomotive engineer in the world, died in Baltimore, April 7, of apoplexy, aged 81 years. He had been in the employ of the Baltimore & Ohio Railroad 54 years, and only two years ago was retired on a pension.

WILLIAM LOUGHRIDGE died in Philadelphia, March 21, aged 74 years. Mr. Loughridge resided for many years in Washington and afterward in Baltimore, and was the inventor of the brake known by his name and of many other devices. His brake was one of the first attempts at the use of power brakes on railroads in this country, and was tested by him on the Baltimore & Ohio Railroad, the experiments extending over several years. It has not, however, come into general use.

JOHN C. CAMPBELL died in New York, March 26, aged 72 years. He was born in Cherry Valley, N. Y., and studied engineering, his first work of importance being on the Croton Reservoir under Mr. Jervis. Later he located and built a portion of the Hudson River Railroad, and in 1850 he went to Panama, where he superintended the building of the western half of the Panama Railroad. He was afterward employed in the construction and management of railroads in Indiana and Wisconsin for several years. On returning to New York he was appointed Chief Engineer of the Croton Aqueduct, and was subsequently Chief Engineer of the Department of Public Works of New York City for a number of years. He also acted as Consulting Engineer on some important water-works in Cali-

fornia. Mr. Campbell was a high authority on hydraulic engineering and the construction of water-works. For some time past he has been in failing health and has done no active work.

ALEXANDER L. CRAWFORD, who died in New Castle, Pa., April 1, aged 76 years, was one of the first who introduced iron manufacture in the Shenango Valley in Pennsylvania, having settled in that region in 1835 and built a blast-furnace and shortly after a rolling-mill. He continued in the iron business until his death. He was the principal builder of the New Castle & Beaver Valley Railroad, and was also largely interested in the St. Louis, Salem & Little Rock Railroad in Missouri, and the Nashville & Knoxville Railroad in Tennessee. He also owned iron and coal mines in Kentucky and in the Lake Superior regions.

T. G. HALSKE, of the well-known firm of Siemens & Halske, died in Berlin, Germany, March 17, aged 76 years. A native of Hamburg, he went to Berlin as a mechanic, and as early as 1844 set up a small mechanical shop there. Soon after this Mr. Werner Siemens made his acquaintance, and there, in Halske's workshop and assisted by Halske's remarkable practical skill, was enabled to experiment on and prepare for public exhibition his first inventions in the telegraphic line. In 1847 Siemens and Halske joined company in establishing a Telegraphic Institution which has since spread into those large works at Berlin, Charlottenburg, and elsewhere, which give employment to thousands of workmen, and the productions of which have carried the name and the fame of Siemens & Halske all round the globe.

FREDERICK GRAFF died suddenly in Philadelphia, March 30, aged 72 years. He was a son of Frederick Graff, Engineer of the Fairmount Water-Works, and was educated as a civil engineer. He served for several years as assistant to his father, and in 1847 succeeded him as Superintendent and Chief Engineer, holding that office until 1873 with the exception of the three years from 1853 to 1856, when he was out of office. In 1873 he retired from active work in his profession, but was engaged with many organizations and public bodies in Philadelphia, and was one of the best known citizens of that city. In 1880–81 he was President of the Engineers' Club of Philadelphia, and in 1885–86 he was President of the American Society of Civil Engineers. Although retired from office, he continued to act as consulting engineer, and his last professional service was as one of the Board of Engineers appointed by the United States Government to examine and report upon the Washington Aqueduct Tunnel.

PERSONALS.

W. F. HENDERSON has been appointed Master Mechanic of the Fort Worth & Denver Railroad, with office at Fort Worth, Tex., succeeding JOHN F. WHITE, who has resigned.

WILLIAM KENT, well known as a consulting engineer, now has his office at Room 125, *Times* Building, New York. Mr. Kent is now the representative in New York of the Pittsburgh Testing Laboratory of Hunt & Clapp.

F. W. D. HOLBROOK has resigned his position as Manager of the Seattle, Lake Shore & Eastern Railroad, and the position has been abolished. Mr. Holbrook will probably be engaged in the construction of the new extension of the road.

D. E. HERVEY is now Associate Editor of *Electric Power*. He is a gentleman of long experience in editorial work, and will make his training and ability felt in the columns of our excellent contemporary, which already stands high among the journals in its field.

W. F. ELLIS has resigned his office as Roadmaster of the New York, Providence & Boston Railroad, and has accepted a position with the Dunham Manufacturing Company, which he will represent in the interest of the Servis tie-plate and the Davies spike.

S. T. WAGNER, Superintendent of the Phœnix Iron Company, will go out in the field in charge of the erection of the Ohio River Bridge between Louisville and Jeffersonville, now being built by this Company. Mr. Wagner's health has been poor for some time past, and he hopes to benefit it by field work.

H. B. STONE has resigned his position as Second Vice-President of the Chicago, Burlington & Quincy Railroad Company, to become President of the Chicago and the Central Telephone companies. Mr. Stone has been some 12 years on the Chicago, Burlington & Quincy, serving as Superintendent of Motive Power, General Manager and Vice-President.

MARSHALL M. KIRKMAN, Second Vice-President of the Chicago & Northwestern Company; STUYVESANT FISH, President of the Illinois Central; J. C. PEASLEY, Vice-President of the Chicago, Burlington & Quincy; CHARLES C. WHEELER, a railroad officer of long service and high reputation; and J. T. JEFFREY, recently General Manager of the Illinois Central, have been appointed directors of the International Exposition in Chicago.

THE following changes in stations and duties of the Corps of Engineers are announced: MAJOR CHARLES W. RAYMOND relieves CAPTAIN EDWARD MCGUIRE, who proceeds to Louisville, Ky., taking charge of the work heretofore under MAJOR AMOS STICKNEY. The last-named officer is transferred to Buffalo, N. Y., where he relieves CAPTAIN FREDERICK A. MAHAN, who is assigned to duty as Engineer of the Fourth Light-house District, in place of Major Raymond. FIRST LIEUTENANT JAMES C. SANFORD has been transferred from New York to St. Louis, where he will act as Secretary and Disbursing Officer of the Mississippi River Commission.

PROCEEDINGS OF SOCIETIES.

General Time Convention.—The spring meeting was held in New York, April 8. The President, Mr. H. S. Haines, made an address on the Question of Existing Relations between Railroad Companies and Labor Unions, and treating also of other matters.

The Committee on Standard Code of Train Rules reported that the code was now used by 93 companies operating 65,734 miles of railroad, an increase of 14 companies and 13,467 miles since the October meeting.

The Car Service Committee recommended that no definite action should be taken until the fall meeting upon recommendation to substitute a mixed mileage and per diem rate of payment for car service for the old mileage rate. This was adopted.

The following officers were elected for the ensuing year: President, H. S. Haines; Vice-Presidents, James McCrea and J. F. Royce; Secretary, W. F. Allen; Members of Executive Committee, H. Stanley Goodwin and J. G. Metcalfe; Members of Committee on Train Rules, J. T. Harahan and H. Walters.

It was decided to hold the next meeting in New York on the second Wednesday of October.

Master Mechanics' Association.—The Secretary has issued a circular stating that it will not be possible to hold the Convention in June at Chattanooga, as the Lookout Mountain Hotel will not be completed in time. As Buffalo and Montreal, the other places indicated for the Convention, are distant from Old Point Comfort, where the Master Car-Builders will meet, it was deemed best to give members the opportunity to vote on a new place of meeting, and they have accordingly voted to hold the Convention at Old Point Comfort.

American Society of Civil Engineers.—At the regular meeting, April 2, it was announced that the Committee on Rail Sections was not discharged. The resolution providing for a special Committee on Units of Measurement was carried and that for a Committee on Sewer Nomenclature was lost. The death of Frederick Graff, past President of the Society, was announced.

F. W. Watkins read a paper on Tunneling Surveying on Division No. 6, Croton Aqueduct, which was discussed by several members who had had experience in the work.

The tellers announced the following candidates elected:

Members: James H. Covode, Chili, South America; George S. Davison, Pittsburgh, Pa.; Lieutenant-Colonel Peter C. Haines, U. S. Eng., Washington; Alexander W. Jardine, Queensland, Australia; Thomas McCann, Hoboken, N. J.; Gaylord Thompson, Yonkers, N. Y.

Associate: Lewis R. Pomeroy, New York.

Juniors: Charles W. McMeekin, Des Moines, Ia.; Robert W. Creuzbaur, New York.

AT the regular meeting, April 5, the Secretary reported the special meetings of the Board of Directors and past officers, and the action taken at these meetings on the death of Mr. Frederick Graff. The report and minutes were adopted and remarks were made on the character of Mr. Graff.

The Secretary presented for Mr. Frank Cooper notes on Railroad Engineering Drawing, which were discussed by members present. Mr. E. H. Brown stated that he used no tracings, but had blue prints made directly from the finished drawings.

Mr. Edwin S. Crawley described a new form of Steam Valve in which packing is used instead of the ground seat. He exhibited a model and drawings. There was some discussion by members present.

AT the regular meeting, April 16, a paper by Mr. William Metcalf on Tests of Steel Bands was read and discussed.

Mr. John Bogart read a paper on the Results of Some Tests of Cements, which called out a long discussion.

THE annual Convention for 1890 will be held at Cresson, Pa., on the western slope of the Allegheny Mountains. The date will be near the end of June. The exact date and details will be announced in a later circular.

Boston Society of Civil Engineers.—At the annual meeting in Boston, March 19, David A. Harrington, John L. Howard, Clarence A. Perkins and Frank H. Snow were elected members.

The annual reports of the officers were presented and accepted. The permanent fund now amounts to over $3,000. The reports of the special committees were presented, and their discussion postponed to the next meeting.

Officers were then elected for the following year as follows: President, Clemens Herschel; Vice-President, J. R. Freeman; Secretary, S. E. Tinkham; Treasurer, Henry Manley; Librarian, F. W. Hodgdon; Director, F. Brooks.

Mr. Cope Whitehouse delivered an address upon Irrigation in Egypt, which was illustrated by maps and photographs.

Civil Engineers' Club of Cleveland.—At the annual meeting in Cleveland, March 11, the reports of the officers were presented and accepted. The standing Committees on Civil Engineering and Surveying, on Railroad Engineering, on Architecture and on Mechanical Engineering presented their yearly reports, which were read and accepted.

The following officers were elected for the ensuing year: President, W. H. Searles; Vice-President, J. L. Gobeille; Secretary, C. O. Palmer; Corresponding Secretary, S. J. Baker; Treasurer, N. P. Bowler; Librarian, C. N. Barber; Member of Board of Managers of the Association of Engineering Societies, Professor Cady Staley.

AT the regular meeting in Cleveland, O., April 8, H. F. Coleman was elected a member. The President made some remarks relative to the present condition of the Club and the necessity for better quarters.

In accordance with votes of the Club, the following committees were appointed: To confer with the Committee of the American Society of Civil Engineers on Affiliation between the Societies: A. Mordecai, J. Whitelaw, J. F. Holloway, W. R. Warner, H. C. Thompson.

To confer with the Cleveland Architectural Club in relation to the Joint Use of Rooms: Messrs. Barber, Staley and Palmer.

To carry out suggestions made by the President on the question of Increased Facilities for the Club: W. R. Warner, S. F. Wellman, W. Chisholm, H. S. Claflen and James Barnett.

Mr. Whitney, of the Pratt & Whitney Company, Hartford, Conn., by invitation made a short address to the Club.

Mr. Ambrose Swasey read a paper on the Eiffel Tower, which was illustrated by a number of diagrams and a large model of the tower. This paper was discussed by the members present.

Engineers' Club of Cincinnati.—At the February meeting Charles H. Meeds was elected a member and several applications were received. A budget of short papers by various members was read, the subjects chosen being:

1. Some Curiosities of our State Boundaries.
2. Turn-Outs.
3. Phonography as an Aid to Engineers.
4. Elevation of Outer Rail on Curved Trestles.
5. A Method of Pile Driving under Special Conditions.
6. A Plea for a Natural Motor.

New England Railroad Club.—At the regular monthly meeting in Boston, April 9, the subject for discussion was Locomotive Boilers. Mr. H. L. Leach read a carefully studied paper on Boiler Construction, describing present practice and outlining the best practice as proved by experience. He also discussed the question of steel and iron for boilers, and said that there were some boilers in use in New England that are over 30 years old and good yet. The discussion was continued by Messrs. Lauder and other members.

Western Railroad Club.—At the regular meeting in Chicago, April 15, the subjects for discussion were Counterbalancing Locomotives; the Master Car-Builders' Interchange Rules, and Journal-Boxes.

This Club has resolved to publish hereafter its proceedings in pamphlet form, and has requested the various technical journals to give no account of the discussions prior to the official publication.

Western Society of Engineers.—At the regular meeting in Chicago, April 2, Mr. Jenison explained his plans for a World's Fair building.

The Chicago Railroad Problem was discussed at length by Messrs. J. F. Wallace, Isham Randolph, H. C. Alexander, President Cooley and others, in relation to terminals, rapid transit and street crossing accidents. The opinion was expressed by several members that the Society ought to formulate a plan and submit it for public discussion. The subject was continued to the next meeting.

Tacoma Society of Civil Engineers & Architects.—At a special meeting in Tacoma, Wash., March 7, a paper was read by E. S. Alexander on the Water Supply of the city of Tacoma. This was followed by a discussion which showed that an excellent supply could be obtained from the adjacent streams without using Green River, the supply from which was not pure.

AT the regular meeting, March 21, a paper on the Preservation of Wooden Piles by Colin McIntosh was read. Specimens were shown of piles broken off 40 ft. below low water, upon which the bark was still preserved, but the body of the pile had been completely destroyed in the four months by the teredo. A specimen was shown of a strip of pile, which had been protected by creosoted strips of wood nailed to it. Another plan proposed was to first cut slabs from the pile which is then sheathed with three-ply building paper and the slabs afterward nailed on to protect the paper.

Papers on Street Improvements were read by D. B. Ogden and C. B. Talbot, advocating plans for paving, etc., which were thoroughly discussed by members present.

Engineering Association of the Southwest.—The regular meeting was held in Louisville, Ky., April 11, with a large attendance. Addresses of welcome were made by Louisville engineers. The following elections were announced:

Members: Robert L. Engle, Graham Macfarlane, Harry P. McDonald, Louisville, Ky.; Thomas Sharpe, Nashville, Tenn.

Associates: Lewis Collins, Udolpho Sneed, James B. Speed, Louisville, Ky.

A communication from the American Society of Civil Engineers relating to affiliation with local societies was referred to the Executive Committee.

Mr. Charles Hermany, Chief Engineer of the Louisville Water Company, read a paper on Excavating under Pneumatic Pressure, which, besides giving a general account of the different methods used, gave a description of the O'Connor Excavating Bucket, which was used in sinking the large caisson for the foundations of the new pumping stations in the Ohio River at Louisville.

Mr. Robert L. Engle read a paper describing the foundations of the Louisville & Jeffersonville Bridge, now under construction over the Ohio River. This was followed by a discussion, and at its close Messrs. O. H. Landreth, W. L. Dudley and G. W. Shaw were appointed a Committee to report on the present state of knowledge relating to the cost of the setting of cements and mortars.

On the day following the meeting the members of the Association made by invitation a trip over the Louisville Southern Railroad, inspecting the new bridge at Tyrone, and also visited the Louisville Water-Works and the works in progress on the Louisville & Jeffersonville Bridge.

NOTES AND NEWS.

Steatite Paint.—The use of steatite or soapstone, as the basis of an anti-corrosive paint, was advocated in a paper read at the meeting of the Institution of Naval Architects. It was said that it will not mix properly or dry with linseed-oil, dryers, turpentine, etc., but it has been embodied as a pigment or paint

with a quick-drying varnish, and as an anti-corrosive it was a success.

Adams's Exhaust-Pipe.—Figs. 1 and 2 represent longitudinal and transverse sections of Adams's "vortex" blast-pipe, which is the invention of Mr. W. Adams, Locomotive Superintendent of the London & Southwestern Railway. The main object of this invention is to equalize the draft through the tubes of the locomotive and thus to prevent the destructive action of the blast, which, with ordinary blast-pipes, acts with too great intensity through the upper rows of tubes. To overcome this Mr. Adams makes the exhaust orifice *A A* of annular form, shown clearly in the plan below fig. 2. The lower part of the exhaust-pipe is made of a bifurcated form, somewhat like a pair of trousers, the two legs or branches *B B* being attached to the exhaust-pipes *E E*. The branches *B B* have an opening, *F*, between them, and unite in the annular opening *C C* above the partitions *D D*, shown by dotted lines in fig. 2 and black shading in fig. 1. Inside of the annular nozzle *A A* there is a cylindrical central passage, *G*, which communicates directly with the opening *F*. When steam escapes from the opening *A A* it draws the air with it on the outside of the exhaust-pipe *P P* and of the escaping current of steam. It also creates a partial vacuum in the central passage *G*, which draws air from the opening *F*, and from the lower part of the smoke-box and lower rows of tubes. In this way the draft in the upper and lower tubes is equalized, which, it is said, results in a material economy in fuel consumption.

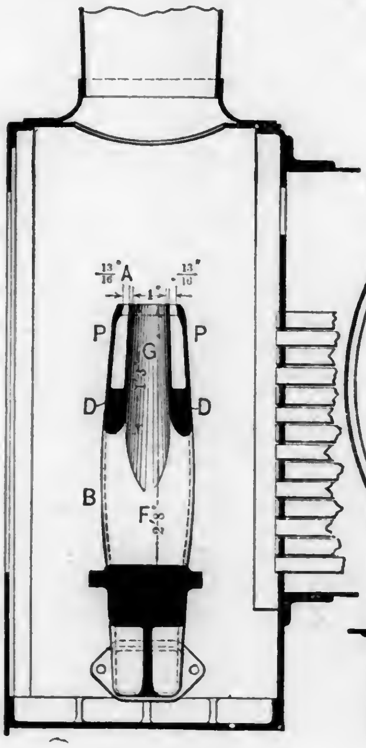


Fig. 1.

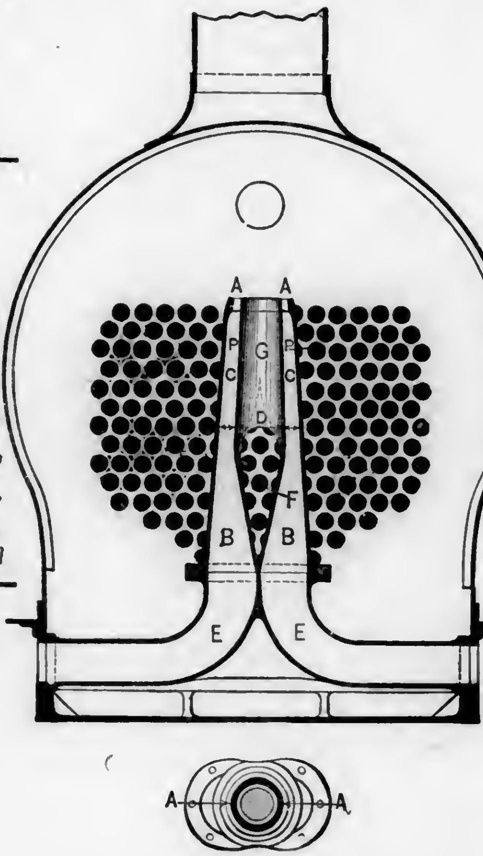


Fig. 2.

Extension Rails for Turn-Tables.—*Engineering* for April 4 contains an illustration and description of an arrangement of extension rails for lengthening turn-tables, which are too short for the "bogie" engines which are coming into use more and more in England. These rails are made to extend beyond the edge of the turn-table when it requires to be lengthened out. They are of an inverted ∩ section, and rest on top of the rails on the table when in use. The outer ends of the extension rails must be elevated to clear the coping of the turn-table pit. Consequently they are made so as to form an inclined plane from the fixed rails. From the engravings it appears that after the engine is turned it would have to be backed off of these extension rails, which can then easily be moved by the mechanism provided so as to lie parallel to and within the fixed rails. The engine can then be run off of the turn-table. This arrangement offers a cheap and ready means of adapting old turn-tables to modern requirements.

The Rule of the Road at Sea.—At the annual meeting of the British Institution of Naval Architects which has just been held, a paper on the recent Washington Maritime Conference was read by Admiral Colomb. This paper, *Nature* says, "was practically reduced to a consideration of the rule of the road at sea. The general opinion of the authorities assembled appeared to be that the present rule of the road is very well as it stands, with the exception that the 'holding-on ship' should not be required, or even allowed, to slacken her speed. This seems in conformity with common-sense. If two ships are converging toward a point, say at right angles to each other, and one shifts her helm to go under the other's stern, if the second, or holding-on ship, slacken speed, the probability will be that the giving-way ship will crash into the other's broadside or cross her bows; in the latter case, there is probability that the holding-on ship will give the other her stem. What is most wanted when danger of collision arises, is certainty on each vessel as to what the other may be going to do. If the holding-on ship never slacken speed—is not allowed to slacken speed—then the other vessel knows exactly what course to take; as the law stands, the quartermaster, or officer in charge, is never quite sure until the last minute, especially at night, whether the other ship considers there is danger of collision or not, and, therefore, whether she will slacken or keep to full speed."

Boilers with Weldless Rings.—A correspondent of the London *Engineer* writes to that paper—Sir Joseph Whitworth & Company have in contemplation the erection of additional works in the neighborhood of the Manchester Ship Canal, where they propose introducing an important departure from the present practice in the erection of marine and other boilers. It will be remembered, at the recent Manchester Exhibition the above firm exhibited a weldless boiler ring, 12 ft. diameter by 6 ft. long, which at the time attracted very considerable attention; and at their new works it is their intention to lay down plant for the construction of boilers built up of weldless rings, for which it is claimed that while they reduce the weight of the boiler by 30 per cent., it is at the same time kept up to its full strength. So far, no marine boilers have been constructed on this principle, but that there is no difficulty in the manufacture of these weldless boiler shells for the above purpose has been evidenced by what Sir Joseph Whitworth & Company have already accomplished. In some instances these shells would go up to 14 ft. diameter, and the practically insurmountable difficulty of conveying such large pieces of work either by rail or road renders it, of course, necessary that works for their manufacture should be placed at the water side.

The Largest Gun.—The largest gun yet manufactured was recently completed at the Krupp Works in Essen, Germany, for the fortifications at Cronstadt in Russia. It is of the finest quality of steel and weighs 135 tons; the caliber is 16¼ in., and the total length 44 ft. The greatest diameter, over the outside rings, is 6 ft. 6 in. The estimated range is about 12 miles. Each shot fired from this gun costs about $1,500. At the trial of the gun, the projectile, 4 ft. long and weighing 2,600 lbs., was propelled by a charge of 700 lbs. of powder and penetrated 19 in. of armor, going 1,312 yards beyond the target. It was carried from Essen to Hamburg on a car specially constructed for the purpose. Work is reported as now being pushed forward on several guns of this class.

Export of Scotch Locomotives.—During the first three months of this year there were exported from Scotland locomotives of a total value of £90,469 against a quarterly average of £90,000 last year and of £71,000 in 1888. The value of those shipped during the first quarter of this year to the Continent was £50,000, and those to Australasia £14,000.

Petroleum in Roumania.—The richest petroleum districts in Roumania are situated southeast of the Carpathian Mountains. In many places in this district, especially at Ploiesti, the ground is charged with gas to such a degree that it is only necessary to bore a hole and a jet of inflammable gas issues at once. The wells here are in general from 160 ft. to 230 ft. deep, though some are as much as 400 ft. in depth, and still deeper borings are now being put down.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

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NEW YORK, JUNE, 1890.

AN International Exhibition of Mining and Metallurgy is to be held in London, beginning in July next and continuing until September. The Board of Managers includes a long list of distinguished persons. The subjects within the scope of the Exhibition include mining machinery of all kinds, especially appliances for the mining of different metals, such as gold, silver, copper, tin, lead, iron, etc.; coal mining; petroleum; assaying and testing; electricity in its application to mining; explosives and their use; mining and metallurgical literature, and in general everything relating to the mining of ores and the extraction of metal from them. Exhibits are invited from all countries.

THE present seems to be the age of international exhibitions, and the latest one noticed is to be held in the Island of Jamaica under the auspices of the Government of that colony. In this case a special desire is expressed to secure the co-operation of American manufacturers, and a large space will be reserved for exhibits from this country. The Exhibition is represented in the United States by Mr. Thomas Amor as Secretary, and he may be addressed at No. 280 Broadway, New York City. This seems to be a favorable opportunity to promote trade between this country and the West Indies, as there will probably be a large attendance from all the islands.

ACCORDING to accounts given in German technical papers, the locomotive builders of that country have formed an agreement to prevent underbidding for contracts and to keep up the price of locomotives, which, it is claimed, had fallen to an excessively low point in consequence of too great competition. The agreement is to continue for five years, but its terms, or the manner in which it is to be enforced, are not stated.

In this connection it may be of interest to note the present prices of locomotives in Germany. In the bids recently received for a large order for the Prussian State Railroads, the prices named were, for express passenger locomotives, $12,114; for ordinary passenger locomotives with tenders, $11,626; for freight locomotives, $10,710. These bids, it may be noted, were put in after the new agreement had been made, and represented an increase of from 16 to 30 per cent. over previous prices.

THE manufacturing industries of the Pacific Coast have been restricted in their development to a considerable extent by the high cost of fuel, which has been sufficient to offset the cost of transportation, and thus enable the Eastern or foreign manufacturer to compete with the local factories. In California there is very little coal, and that not of good quality. The new State of Washington, however, has coal measures of large extent, and the coal is of excellent quality. Its development has already begun, and is proceeding as fast as transportation facilities are provided, so that there is little doubt that in a few years its mines will be able to supply the demand of all the Pacific States, and the ports on Puget Sound will be the shipping centers of a great coal traffic.

This abundant supply of fuel, with its other mineral products and its extensive tracts of fine timber, seems to show that in the future Washington will be the great manufacturing State of the Pacific slope, and will in time hold a position corresponding to that of Pennsylvania in the East.

TWO bills have been introduced in Congress at the present session to provide for the use of safety appliances on railroad freight trains. The first, which was prepared by Senator Allison of Iowa, provides that all companies engaged in interstate commerce shall provide all new cars, and all cars brought into shop for repairs, with automatic couplers, and that after January 1, 1895, the use of cars not provided with such couplers shall be prohibited. It is also provided that all locomotives shall be equipped with driver brakes, and that after January 1, 1893, it shall be unlawful to run any train which has not a sufficient number of cars in it equipped with power or automatic brakes to give the control of the train to the engineer. A penalty of not less than $500 nor more than $1,000 is provided for infractions of the law. The Interstate Commerce Commission is charged with the duty of requiring reports from all companies under its jurisdiction as to the number of cars and engines used and the number equipped with automatic couplers and with brakes. A final provision authorizes companies to refuse to receive cars not properly equipped.

The second bill, which has been introduced by Senator Collom of Illinois, provides for the appointment of a Board of five members, at least two of whom must be practical railroad men and two versed in car construction. This Board is to investigate the car couplers in use and any designs that may be presented, and to make such tests as may be necessary to decide what type of coupler is best, and to report its conclusion to the Interstate Commerce Commission. The Board is given one year in which to make such a report, and after its decision is presented and filed, the railroad companies are required to adopt such couplers as may be decided upon, and to introduce and equip their cars with the same under heavy penalties, a reasonable time being given to accomplish the work.

There does not seem to be much prospect that either of these bills will pass at the present session, as the time of Congress is pretty fully taken up with other matters. In the mean time, the whole subject of Federal regulation of

safety appliances was to be considered at the Conference in Washington, May 28, at which it was expected that the Interstate Commission and all the State Commissions would be fully represented.

THE total mileage of track laid on new railroads in the United States up to May 1 of this year is reported by the *Railway Age* at 1,084 miles. The early part of the year was unusually favorable for tracklaying, owing to the absence of severe cold and snow over a great part of the country, and this may possibly have had some effect upon the extent of the new mileage. It is nevertheless true that the first part of the year is that in which the least tracklaying is done, and an addition of 1,100 miles during one-third of the year may be taken to indicate that the railroad building of 1890 will be at least equal to that of last year, when 5,200 miles were built, and may possibly exceed it.

As was the case last year, a large proportion of the new track was in the Southern States, Georgia leading with 170 miles and North Carolina coming second with 135 miles; no other State reports over 100 miles. In New England and the Middle States the mileage was small and no large increase is reported in the West or Northwest, while on the Pacific Coast railroad building seems to have come to a stand-still for the present.

THE city of Newark, N. J., has erected in its chief public park a statue of Seth Boyden, an inventor who did much to start the old New Jersey town on its prosperous career as a manufacturing city. Mr. Boyden was engaged in various occupations; he invented the process of making patent leather, that of making malleable iron castings, and many improvements in steam-engines, in building which he was engaged for many years. He was also one of the early locomotive builders, having constructed in his shops in Newark in 1837 two engines for the Morris & Essex Railroad, which successfully worked the grade of 140 ft. to the mile between Newark and East Orange—a feat unprecedented in those days. It is claimed that on these engines he used for the first time outside connections and a sort of link motion, the drawings of which have, unfortunately, been lost. He did not continue long in the locomotive business, the two engines named and one which was sent to Cuba being all that were built in his shop.

Business complications left Seth Boyden a poor man in his old age, but he was undoubtedly a mechanic of great ability, and the city where he spent nearly all his active life has done well in honoring his memory.

THE project for the American International Railroad has been brought formally before Congress by a brief message from the President transmitting a note from the Secretary of State upon the agreement reached in the late so-called Pan-American Conference. In this message Congress is asked to appropriate the sum of $65,000, which would be the estimated share of the United States in the cost of the preliminary surveys required.

The proposed line is intended to connect the United States with the different South American countries, and for that purpose it is proposed to make use of the railroads already built in Mexico, Peru, Chili and the Argentine Republic, the new line to fill in the gaps now existing between those different countries. In the recent Conference an agreement was reached for the making of a survey to ascertain the best and most economical routes under the direction of an International Commission, the expense to be shared by the several nations concerned in proportion to population. The headquarters of the Commission are to be located in Washington, and its first meeting will probably be held in October next. The United States will be represented in the Commission by three members, and it is probable that the actual work will be placed in charge of a small sub-committee.

LATER advices concerning the breakdown of the engines of the *City of Paris*, while they contain much information as to the condition of the engines and of the ship, do not yet make altogether clear the cause of the accident. The low-pressure cylinder, which gave way, was completely broken up, and judging from the engravings published in our contemporaries, *Engineering* and the *Engineer*, the engine-room presented the most extraordinary scene of destruction ever found on an ocean steamer. The after, or low-pressure cylinder, was a complete wreck, and almost every part of the engine was out of place, although the intermediate and high-pressure cylinders were not badly broken. Contrary to the first advices, the bottom of the ship was not injured, the water which came in having entered entirely through the valves, which could not be closed, as it was impossible for the engineers to reach them.

As to the cause of the accident, there is still some difference of opinion; but the weight of evidence seems to show that it resulted from the breaking of the propeller shaft, and that that break occurred in consequence of the wearing down of the outboard bearings of the shaft. The brass sleeve, it was found when the ship was docked, had entirely disappeared with the exception of two rings, probably the collars at the end. The propeller shaft itself was practically undamaged, but the metal studs which attached the sleeve were worn down level with the shaft. The result of this wear would be the dropping of the after end of the shaft, throwing an enormous strain upon the level portion, and under this strain there was a fracture close to the next point of support, which was in the stern close to where the shaft emerged from the ship. The breaking of the shaft would, of course, permit the engines to race at a high speed, and the immediate result was the breakage of the low-pressure cylinder, probably in consequence of the piston striking the head. It may be added that careful examination showed no defective metal in any part of the shaft or engines.

One peculiarity of this accident is that when the engine gave way sufficient damage was done to the engine driving the other screw to stop that also. Among the advantages urged in favor of the twin-screw system has been the improbability of both engines giving way at once, and it is somewhat strange that in the first serious accident occurring to a large steamer built with twin-screws both engines should be stopped. As has been already stated, it is evident that the danger to the ship resulted chiefly from the manner in which the outboard valves were worked and the impossibility of closing them anywhere except from the engine-room. If any special lesson is taught by the accident beyond this, it is the necessity of strengthening the outer bearings of the propeller shaft.

THE Committee which has in charge the arrangements for the American meeting of the Iron and Steel Institute of Great Britain held a meeting in New York recently, and has about completed the arrangements. It is understood that the members of the Institute will arrive in New

York about October 1, and will be present at the meeting of the American Institute of Mining Engineers, which is to be held in New York at that date. It is stated that about 450 members have signified their intention to join in the meeting, and that they will be accompanied by some 50 ladies. After the meeting two excursions have been arranged: One through the coal and iron regions of Pennsylvania to Pittsburgh, thence to Chicago and the copper mines of Lake Superior, returning by Detroit and Niagara Falls. The other excursion will go to Birmingham, Ala., by way of Cincinnati and Chattanooga, returning through East Tennessee and Virginia. The International Conference, in which the British and American associations will join, will be held in Pittsburgh. It is also expected that a number of members of the German Union of Iron Manufacturers will be present, with metallurgists from other European countries.

THE last great bridge proposed is one to cross the Mississippi at New Orleans, and plans have been prepared for this bridge by Mr. T. C. Clarke, the well-known engineer. His design is for a main bridge of three spans, the central one to be 1,200 ft. with a clear height of 180 ft. above the water, while the shore spans would be 800 ft. each. On account of the low level of the banks on either side of the river a very sharp grade will be necessary to rise to the height required to avoid interference with navigation, and it is proposed to operate the railroad line over the bridge on the Abt rack-rail system. The great difficulty at New Orleans probably will be in finding proper foundations for the piers, and long spans would be advisable not only on account of navigation, but also of the expense of foundations. A draw-bridge is not admissible at New Orleans, and indeed there is great opposition from the local and river interests to a bridge of any kind at that point.

THE naval bill for this year is still hanging between the House and the Senate, and it is uncertain how large an appropriation will be made for new vessels, and what policy will be adopted in building them. As has been before noted, considerable opposition was manifested in the House to the policy of building battle-ships which was outlined in Secretary Tracy's report, and there seems to be no prospect at present of any progress toward the adoption of the extensive programme outlined by the Naval Policy Board. The preference of the House, as shown in the discussions, was evidently for more cruisers if any new vessels were to be built, while the Senate is more inclined toward the Secretary's plans.

No progress has been made with the bill which provides for subsidizing merchant vessels, which can be used on occasion as a naval reserve, which can be armed and put into service as cruisers. Such a measure seems to have many advantages, and if an appropriate bill of this kind could be passed, good results might doubtless be expected. The Secretary has recommended a special appropriation to provide the necessary arms and equipment for the battalions of the Naval Reserve which have been formed in New York and elsewhere, and this also seems to be a desirable measure, especially as the expense would not be great. Meantime work continues on the naval vessels already decided upon and in progress, and the additions to the active fleet during this and next year will be very considerable.

The gun appropriations are also still undecided, but there seems to be little doubt that considerable amounts will be made available for the construction of new guns both for the Navy and for the Army.

As noted elsewhere, the present month will probably conclude the official trial trips of the cruiser *Philadelphia* and the torpedo boat *Cushing*. From preliminary trials the *Philadelphia* is expected to make an excellent showing, and to prove herself at least as fast a vessel as the *Baltimore*. The *Newark* and the *San Francisco* will probably also be ready for their trial trips before long. During the present month also bids will be received for the new armored ship, and the contract for her construction will probably be let.

IT appears from the records of the Bureau of Navigation that there were built in the United States in 1889 a total of 1,077 vessels registering 231,134 tons. Of these 769 were built on the seaboard and were generally of small size, their total tonnage being 111,852, or an average of 145⅓ tons each. The number built on the Mississippi and its tributaries was 83, and their total tonnage 12,202, an average of 147 tons each.

The most important shipbuilding of the year was on the Lakes, where 225 new vessels are reported, of total tonnage of 107,080 tons—which is very nearly equal to the seaboard tonnage. The number of vessels was much less, but their size greater, the average being 476 tons each. The lake building was thus the more important from its size, including a number of large carriers.

It may be noted that the total tonnage reported for last year shows a large increase over 1888 and 1887, and is more than three times as great as the total for 1886.

THE pig iron production of Great Britain last year showed an increase of about 4½ per cent. over the previous year, the gain being in forge and foundry irons entirely. The steel production showed an increase of about 6½ per cent., although there was a falling off of a little over 3 per cent. in the output of steel rails.

The following table shows the production of pig iron and Bessemer steel in the United States and Great Britain respectively, in 1889:

	United States.	Great Britain.
Pig iron, tons	8,516,079	8,245,336
Bessemer steel rails	1,691,264	943,048
Bessemer steel, other than rails	1,584,364	1,665,122

The increase in the United States over 1888 was much greater than in Great Britain, the gain being 17½ per cent. in pig iron, 9 per cent. in steel rails, and 31½ per cent. in steel in other forms.

THE last report of the Hungarian State Railroads shows that on those lines in the year covered—1888-1889—no passenger was killed by accident. There were, however, 59 employés killed and 158 injured, while of other persons 76 were killed and 38 injured. Of this last-named class most apparently of the casualties resulted, as in this country, from unprotected crossings and from persons walking on the track. There was a slight increase in their number over the previous year, which is said to have resulted from the increased traffic. The greatest interruptions to traffic recorded were not from accident, but from snow blockades and floods.

The report notes that a decrease in the number of slight accidents and an increase in the general convenience and accommodation of travellers have resulted from several

measures which have been adopted by the administration. The first of these is the increased use of continuous or train brakes, both the Westinghouse automatic and the Hardy vacuum brake being in use. In one case experiments have also been made with the Carpenter air-brake, but its use does not seem to have been extended.

In the heating of carriages, experiments have been made with steam heating, using steam from the locomotive, and have resulted so favorably that this system will probably be adopted for all passenger trains. During the present season already 1,040 cars have been provided with the necessary equipment.

A minor improvement has been the introduction of spark-arresters of American pattern, which have been applied to several lines where a very soft coal is in use with greatly increased comfort to passengers and without the unfavorable results as to combustion which some of the German mechanics had predicted.

THE MECHANICAL ENGINEERS' CONVENTION.

THE meeting of the American Society of Mechanical Engineers in Cincinnati was in many respects a successful one; in point of attendance it was fully up to the average, and some work was accomplished. Nevertheless a certain amount of criticism seems to be in order.

The papers, it must be said, were none of them of remarkable interest or weight, and the discussions were chiefly carried on by the younger and inexperienced members. It seems to be a mistake, too, to crowd so great a proportion of the business into one day, as was done on Wednesday. Three sessions of several hours each, filled up with the reading of engineering papers and discussions, furnish rather heavy mental diet for even a vigorous digestion.

The great enemy of meetings of this kind is the temptation of excursions. Some line should be distinctly drawn, and it should be made a rule that it should never be crossed. The morning of every day of the session should be strictly devoted to the business and work of the Society, and nothing should be allowed to interfere with it. Unless such a rule is established and adhered to, there will be, each year, some special occasion for ignoring what is the real occasion for the existence of the Society, and for devoting the precious time of the session to what is alluring and pleasant, but which is sure in time to undermine the organization. An afternoon excursion or visit is a pleasant diversion after a morning of papers, which are often not light reading; whereas a whole day's work or a whole day's play is too often tiresome.

IRRIGATION.

THERE are few subjects which just at present occupy a larger share of public attention than that of the artificial supply of water to the lands extending through a large belt in the Western States and territories, where the rainfall is not sufficient or does not come in the right season to make the raising of crops without irrigation possible or profitable. Projects for the improvement of sections of this region abound, and seem to offer excellent investments for capital; and it is very probable that in the course of the next few years a large amount of money will be expended in this way.

It is quite possible, however, that a considerable portion of this money will be wasted or spent in such a way as to realize only a part of the benefits that might be secured, and while there is undoubtedly a large field open, it is necessary to be very careful, if we would secure the greatest possible benefits from its development.

Attention is called to this by an article in the March number of the *Century Magazine*, written by Major J. W. Powell, the Chief of the Geological Survey, who has had abundant opportunities of studying this subject, and who has probably a more systematic and thorough knowledge of the capabilities of the Western country than almost any other man, so that what he has to say upon the subject is well worth listening to.

There is no doubt that a large part of the land included in the so-called Arid or Desert Belt of the West is capable of raising profitable crops under proper conditions, and there is little doubt also that the total rainfall of that region, supplemented by the melting snows from the mountain ranges, is sufficient to fertilize the land if properly applied. In some portions of it the rainfall is sufficient in amount, but does not come at the proper season, while in others, where the amount falling on a given area is not great enough, there are adjoining barren or rocky districts, the rainfall from which can be collected and applied to the better lands. That this should be done in the most economical manner is really to the interest of the whole country.

Two things are to be considered in any irrigation project: The nature of the land and the nature and sources of the water-supply. There are some kinds of soil on which irrigation would be useless, and there are some locations where the land may be good and water available, yet the climate may be such as to make its cultivation unprofitable, as, for instance, on high plateaus or in mountain valleys, where late and early frosts frequently occur, and where other conditions may intervene to prevent the proper ripening of grain or fruits. The danger is in this case, as in many others, of the too hasty assumption that all irrigation will be profitable, and that all that is necessary is to have water and land and to apply one to the other.

It must be remembered that while there are many instances in which small areas of land can be supplied with water from wells or local springs, in a great majority of cases the proper utilization of water for this purpose requires so considerable an expenditure of capital that it can only be done by corporations either formed by local landowners or organized for the purpose of making a profit by selling the water. This has been done successfully in some cases, especially in California and Arizona, and both systems will probably be extended rapidly during the next few years; and here may arise further danger in the conflict of rights of different owners and in the waste or misapplication of water owing to bad methods and want of system. In many cases storage reservoirs will be needed for supply during the dry season, and these must often be placed at considerable distances from the points where the water is to be used. In others, where water may be drawn from a river or stream at different points and by different owners, a proper system of storage can only be secured by a union of private interests, which it is not always easy to obtain voluntarily. Again, it is possible for a district on the lower part of a river to be deprived of its just rights by the action of those controlling the head-waters, and, in short, there are a great number of cases in which injustice

may be done or natural resources wasted and thrown away largely from the ignorance of want of consideration.

It is evident that the great need of the so-called Arid Region is a general system of regulation of water rights. Under the present condition of things this can only be done by the General Government, under whose direct control a considerable part of the territory still is. The State of Colorado has a system of water laws which are said, by those familiar with the subject, to be the best in existence, but elsewhere disputes are already arising, and the condition of the law is such that much injustice is possible. Probably the most that the Government can be expected to do is to complete the explorations which have been undertaken by the Geological Survey with special reference to irrigation, and to provide a general law for the territories which may serve as a model for State action. It will, no doubt, be asked to go further and to undertake at certain points the construction of dams and other works to provide storage reservoirs, and generally to assist in reclaiming this region. Whether it will be wise for the Government to undertake this is a question which admits of a great deal of doubt, and any movement in this direction will be strongly opposed. But there is no doubt that the regulation of the subject by law is much needed, and that action should be taken as soon as possible.

NEW PUBLICATIONS.

THE HUMAN BEAST OF BURDEN: BY OTIS T. MASON, CURATOR OF THE DEPARTMENT OF ETHNOLOGY, NATIONAL MUSEUM. Washington; published by the Smithsonian Institution.

This book is curious and interesting from the showing it makes of the contrast between primitive methods of transportation and our present ones. It is an investigation into the extent to which man bimself has acted as a carrier, and the capacity which he has shown as a bearer of burdens. It seems strange to us, but it is nevertheless true, that there is a large part of the world in which men and women are the chief, if not the only, beasts of burden, and that no inconsiderable part of the world's freight is carried on their shoulders. Even in our own country burdens are still carried and, to go no further, one can meet any day the peddler with his pack, usually a pretty heavy load. In fact, the loads which a man can learn to carry are almost incredible to those who have not seen them.

THE REVISED POCKET GEOLOGIST AND MINERALOGIST; OR, SIXTEEN CHAPTERS ON COAL, OIL, ORES AND OTHER MINERALS, FOR PRACTICAL PEOPLE: BY FREDERICK H. SMITH. Baltimore, Md.; published by the Author.

This is a revision and a combination of two former volumes by the Author, who is a well-known engineer and geologist, and is carefully revised to bring it up to date. It is of small size, convenient to be carried in the pocket, and contains 208 pages of reading matter, accompanied by a full and carefully prepared index. It is not, as may be supposed from its limited size, a complete or scientific treatise on geology, but it is what it professes to be, and that is an exceedingly convenient hand-book for engineers and others engaged in explorations in the field. The object has been to avoid as far as possible purely scientific dissertations, and to make the hand-book practical and easily understood. The 16 chapters include one on Bottom Facts which is introductory and explanatory, while the others are on Coal Measures; Oil and Gas; Iron and Manganese Ores; Gold and Silver Ores; Copper and Tin Ores; Lead and Zinc Ores; Nickel, Cobalt and Chrome Ores; Antimony, Mercury, Platinum and other metals; Gems and Precious Stones; Ornamental and Building Stones; Cements and Clays; Salts and Fertilizers; Mineral Paints; Grits and Spars; Other Valuable Minerals.

This table of contents will give some idea of the general scope of the book, and will also show that it has been necessary to condense as much as possible the information given in order to cover the wide range of subjects. While those who make geology a study will probably reqnire more elaborate books, there are none that will be found more practically useful in this direction.

DRIVING ROAD CHART OF THE COUNTRY SURROUNDING NEW YORK CITY. New York; William M. Goldthwaite, No. 107 Nassau Street.

This is an excellent specimen of a good local map; how useful such a map may be—outside of the special purpose for which this is intended—many of our readers can tell from experience, both of use and of trouble caused by the lack of one.

The present map shows the country to a distance approximately covered by a circle of 20 miles radius, with the City Hall in New York as a center, showing within those limits not only all the towns, villages, railroads, and streams, but all the roads and very many of the houses outside of the towns. It is clearly engraved and on a scale large enough to avoid confusion or indistinctness through the use of too small lettering. For convenience in consultation and to avoid the necessity of spreading out too large a sheet, it is mounted in four sheets, the first showing the country west of the Hudson from Fort Lee to Haverstraw and as far west as Pompton in New Jersey; the second, New Jersey as far south as New Brunswick and as far west as Montclair, with the whole of Staten Island; the third, Long Island as far east as Hempstead; the fourth, the upper part of the City itself, Westchester County up to Sing Sing, and the towns of Greenwich and Stamford in Connecticut. It thus includes nearly all the country closely connected with New York, and about all that can be conveniently covered in a day's drive in either direction. The four sheets are mounted in a handsome leather case of convenient size to be carried.

Altogether this map leaves little to be desired, and the multiplication of such maps will be a service to engineers and many others.

BOOKS RECEIVED.

INSTITUTION OF MECHANICAL ENGINEERS: PROCEEDINGS, OCTOBER, 1890. London, England; published by the Institution.

SEVENTEENTH ANNUAL REPORT OF THE NEWPORT WATER WORKS TO THE BOARD OF COUNCILMEN FOR THE YEAR ENDING DECEMBER 31, 1889. Newport, Ky.; published for the Trustees.

SEVENTH ANNUAL REPORT OF THE BOARD OF RAILROAD COMMISSIONERS OF THE STATE OF NEW YORK FOR THE FISCAL YEAR ENDING SEPTEMBER 30, 1889; VOLUME II: WILLIAM E. ROGERS, ISAAC V. BAKER, JR., MICHAEL RICKARD, COMMISSIONERS. Albany, N. Y.; State Printer.

PAPERS READ BEFORE THE ENGINEERING SOCIETY OF THE SCHOOL OF PRACTICAL SCIENCE, TORONTO: EDITED BY THE COMMITTEE ON PUBLICATION. Toronto, Ont.; published for the Society.

REPORT ON THE EXTENT OF THE FIRST WORKS TO BE CONSTRUCTED FOR SUPPLYING WATER TO SYRACUSE, N. Y.: BY J. J. R. CROES, C.E. New York; the *Engineering and Building Record* Press.

STATISTICAL ABSTRACT OF THE UNITED STATES; 1889, TWELFTH NUMBER: PREPARED BY THE BUREAU OF STATISTICS UNDER THE DIRECTION OF THE SECRETARY OF THE TREASURY. Washington; Government Printing Office. This number of

the Abstract gives statistics relating to Finance, Coinage, Commerce, Immigration, Shipping, Postal Service, Population, Railroads and Agriculture.

Sixth Annual Report of the Philadelphia Company, for the Year ending March 31, 1890. Pittsburgh, Pa.; issued by the Company. This report gives the reader some idea of the extent of the use of natural gas in Pittsburgh. The Philadelphia Company now owns 201 producing gas wells and 703.23 miles of pipe lines. Its gross earnings last year amounted to $3,162,150 and the net earnings to $1,631,721, leaving a profit sufficient to pay dividends of 7 per cent., besides large payments for extension of plant and reduction of debt.

Reports of the Consuls of the United States; No. 114, March, 1890: Prepared by the Bureau of Statistics, Department of State. Washington; Government Printing Office.

Cornell University, College of Agriculture: Bulletin of the Agricultural Experiment Station, March, 1890. Ithaca, N. Y.; published by the University.

A Test of the Efficiency of a Westinghouse Alternating Current Electric Lighting Plant: by Harold P. Browne. New York.

The Sewer Gas Question: by E. S. McClellan, M.D. New York; issued by the Du Bois Manufacturing Company.

The Pelton Water-Wheel: Illustrated Catalogue and Description. San Francisco, Cal.; issued by the Pelton Water-Wheel Company.

Directory of Patent Solicitors: Volume I, No. 1, April, 1890. New York; E. de V. Vermont. This directory purports to give a list of patent lawyers, patent experts, patent agents, pattern and model makers, designers and draftsmen, trade papers, technical publishers and manufacturers specially interested in new inventions—a pretty comprehensive undertaking. It will be issued quarterly.

The Richardson Balanced Slide Valve: Illustrated Catalogue and Description. Troy, N. Y.; issued by the Estate of F. W. Richardson, H. G. Hammett, Manager.

Taunton Locomotive Manufacturing Company, Boiler Department: Illustrated Catalogue and Announcement for 1890. Taunton, Mass.; issued by the Company.

ABOUT BOOKS AND PERIODICALS.

The last quarterly number of the Proceedings of the United States Naval Institute is given up entirely to the report of the Naval Policy Board, which has, of course, great interest for naval officers, and which is likely to call out much discussion among them.

The third of Major Powell's articles on Irrigation appears in the May Century, and treats of the legislation and regulations needed to control water rights in the irrigation districts—a timely and important paper.

The Engineering Society of the State University of Iowa has issued the April number of the Transit, its official paper, in excellent style. It is well printed and contains several excellent papers, notably one on Tests of Iron and Steel, one on the Sewerage of Iowa City, and one on the Location of Bridges. The Transit is certainly a credit to the Society.

In Outing for May the second part of the paper on the Alabama State Troops is given. There are several papers on Yachting, with illustrations of some noted English boats, and other timely spring articles.

The American Machinist has increased its size from 16 to 20 pages—an evidence of well-deserved prosperity which it is very pleasant to see.

In the Journal of the Military Service Institution for May will be found the second part of Lieutenant Bush's Development of Submarine Mines and Torpedoes. Other articles include Infantry Drill, by Lieutenant-Colonel Hawkins; Artillery during the Rebellion, by Captain Hubbell; Practical Work for Infantry, by Lieutenant Avis; the Military Situation in France, by Lieutenant Lockwood; a Regimental Court of Honor, by Lieutenant Wills, and the usual translations and current notes.

In the Arena for May there is a paper of more than ordinary interest on Rock Gases, by Professor N. S. Shaler. Mr. John H. Keatley gives an account of the Gold Fields of Alaska in which he speaks from actual observation in that little known territory.

In the Overland Monthly for May Mr. Vassault brings out strongly the fallacies of Senator Stanford's plan for the relief of farmers. The second part of Mr. Hallidie's Study of Skilled Labor Organizations is a very good paper; there is also a curious article on Chinese Education and Western Science, by Kaw Hong Ben, showing the views of the small progressive element in China.

THE BROOKLYN DRY-DOCK.

The great dry-dock at the Brooklyn Navy Yard was opened on May 10, the first vessel to enter it being the *Puritan*. The dock was built by J. E. Simpson & Company, on the plan devised by Mr. Simpson, which has proved very successful.

The construction of this dock was commenced in December, 1887. The time limit expressed in the contract was 24 calendar months, but many difficult engineering problems were encountered, otherwise the structure would have been ready to receive a vessel last July. This dock is built upon pile foundations throughout, the floor piling being driven in rows, spaced 3 ft. between centers transversely and 4 ft. longitudinally, upon which heavy fore-and-aft timbers of Georgia pine are fitted longitudinally. Upon these fore-and-aft timbers, placed transversely, 4 ft. between centers, are firmly secured heavy Georgia pine floor timbers. Upon these floor timbers are laid longitudinally Georgia pine planking, thus forming the working floor.

The keel blocks are additionally supported by four rows of piles, and capped with heavy Georgia pine timber, running fore-and-aft of the dock. The heads of all foundation piles are also enclosed in a continuous bed of Portland cement concrete, which concrete also fills all spaces between timbers, and rises to the planking or working floor. Open concrete drains or sluiceways are provided on each side of the keel way beneath the floor timbers leading to the drainage or culvert and well, near the entrance of the dock. The sides and head of the dock have an inclination of about 45°; the altars or steps are all of Georgia pine timber, having a rise of 8 in. and 10 in. tread, securely bolted to side-brace timbers, which are supported by piles and abut upon the ends of the floor timbers. The altars are backed with clay puddle as the sides are built up, and the five upper courses of altars and the coping are thoroughly treated with wood-creosote oil. The bilge blocks slide upon oak bearers placed upon every third floor timber.

The iron caisson for closing the dock bears against rubber packing attached to sill and abutments the whole length of the keel and stem, no grooves being used. Two gate and caisson sills are provided, the outer one for use in repairing the main or inner sill. Means of ingress or egress are provided by the continuous altars or steps of the dock, thus materially aiding dispatch and economy in the work of repairs to vessels occupying the dock.

The dimensions of this dock are as follows: Length over all on coping, 530 ft.; length over all inside of caisson, 500 ft.; width on top amidship, 130 ft.; width on floor amidship, 50 ft.; width on floor at entrance, 53 ft.; width on top at entrance, 85 ft.; depth of gate sill below coping, 50 ft. 6 in.; depth of gate sill below high water, 25 ft. 6 in.

The machinery for operating the dock consists of two centrifugal pumps, each 42 in. in diameter, driven by two

vertical engines 28 in. diameter of cylinder by 24 in. stroke, with adjustable cut-offs, steam power being furnished by three steel boilers 13 ft. diameter and 11 ft. long. The entire pumping plant was furnished by the Southwark Foundry & Machine Company, of Philadelphia. These pumps have a capacity of over 80,000 gallons per minute, enabling the dock to be emptied of water (without a vessel) in about 90 minutes, and with a vessel of moderate displacement in much less time. The dock is filled by means of culverts running through the caisson ; there are eight flood gates, each 22 in. in diameter, operated by hand wheels on pump back of caisson. The contract price for the dock complete was $565,893.

In addition to a number of docks built for private parties, Messrs. J. E. Simpson & Company last year completed one at the Norfolk Navy Yard, and they are now building another for the Government at League Island on the Delaware.

TRANSITION, OR EASEMENT CURVES.

To the Editor of the Railroad and Engineering Journal:

LET $A\ B$, fig. 1, be a simple curve of degree D connecting the tangents $A\ V$ and $B\ V$, the ends of which are to be replaced by transition curves beginning on the same tangents and ending at a given number of chains from A and B.

Suppose, for example, $A\ P_2$ to be two chains in length, and suppose it replaced by a transition curve $A'\ P\ P_1\ P_2$ beginning at A', a chain back of A. Let x, y, and z represent the degrees or central angles of the three branches of the transition curve.

We have $x + y + z = 2\ D$ (1).

Since the inclination of the chords $A\ P$, $P\ P_1$, and $P_1\ P_2$ to the tangent $A\ A'$ are $\frac{1}{2}x$, $x + \frac{1}{2}y$, $x + y + \frac{1}{2}z$, we have

$A\ P = c \sin. \frac{1}{2}x$

$t_1\ P_1 = c\left(\sin. \frac{1}{2}x + \sin. (x + \frac{1}{2}y)\right)$

$t_2\ P_2 = c\left(\sin\ \frac{1}{2}x + \sin. (x+\frac{1}{2}y) + \sin. (x+y+\frac{1}{2}z)\right)$ (2).

K being the point on the D-degree curve one chain from A (just above P_1), we have

$t_1\ K = c \sin. \frac{1}{2}D$

$t_2\ P_2 = c\ (\sin. \frac{1}{2}D + \sin. \frac{3}{2}D)$ (3).

We may, in equations (2) and (3), suppose the sines to vary as the arcs, since the terms are small, and since, too, the terms of equation (3) are nearly equal to the corresponding terms in equation (2). This supposition gives

$$\frac{1}{2}x + (x + \frac{1}{2}y) + (x + y + \frac{1}{2}z) = \frac{1}{2}D + \frac{3}{2}D \quad (4).$$

Now, since we have three independent quantities, x, y, and z, and only two equations connecting them, we may make any assumption in regard to them. We will assume that x, y, and z are in arithmetical progression, or that

$$2\ y = x + z \quad (5).$$

Eliminating z from equations (1) and (2), and from (1) and (3), we find

$$x + \frac{1}{2}y = \frac{1}{2}D, \text{ or } 2\ x + y = D \quad (6)$$

and $y = \frac{2}{3}D$ (7).

Now (4) gives $x = \frac{1}{6}D$ (8)

and $z = \frac{7}{6}D$ (9).

Since $x + \frac{1}{2}y$ measures the arc from A' to the middle of $P\ P_1$, and $\frac{1}{2}D$ measures the arc from A to the middle of $A\ K$, it follows that the chords $P\ P_1$ and $A\ K$ are parallel, and that the points P and P_1 are equally distant from the original curve. This facilitates the laying out of the curve. Since the deflection angles from the tangent at P_2 to P_1 is $\frac{7}{12}D$, and to K is $\frac{6}{12}D$, we have

$$K\ P_1 = A\ \ P = P_2\ P_1 \sin. \tfrac{1}{12}D.$$

Hence the degrees of the three branches of a transition curve to replace a 6° curve are $\frac{1}{6} \times 6° = 1°$, $\frac{4}{6} \times 6° = 4°$, and $\frac{7}{6} \times 6° = 7°$.

To replace a 13° curve the degrees of the branches are, $\frac{1}{6} \times 13° = 2°\ 10'$, $\frac{4}{6} \times 13° = 8°\ 40'$, $\frac{7}{6} \times 13° = 15°\ 10'$, etc. Of course the chains or chords may be of any length, and it is not necessary, but convenient, to have them of equal length.

Substituting the above values of x, y, and z in equation (2), and subtracting equation (3) from it, and representing the difference by d, we have

$$d = c\ (\sin. \tfrac{1}{12}D + \sin. \tfrac{17}{12}D - \sin. \tfrac{18}{12}D)$$
$$= c\ (\sin. \tfrac{1}{12}D - (\sin. \tfrac{18}{12}D - \sin. \tfrac{17}{12}D) \quad (11).$$

Since d is very small, but positive, we see that running the transition curve from P_2 toward A', the end of such curve would fall slightly above the tangent $(A\ V)$ to the original curve. For rather an extreme case, suppose $D = 12°$, the central angle $A\ O\ P_2$ being 24°, and c being 100 ft., we have

$$d = 1.745 + 29.237 - 30.902 = .08 \text{ ft.}$$

If $D = 6°$, we have

$$d = 100\ (\sin. 30' + \sin. 8°\ 30' - \sin. 9°)$$
$$= .873 + 14.781 - 15.643 = .01 \text{ nearly.}$$

The curve necessarily ends on the tangent $A\ V$, fig. 1, or on $A'\ A$ fig. 2 ; fig. 2 being an exaggerated view of a part of fig. 1, the same letters on both figures referring to

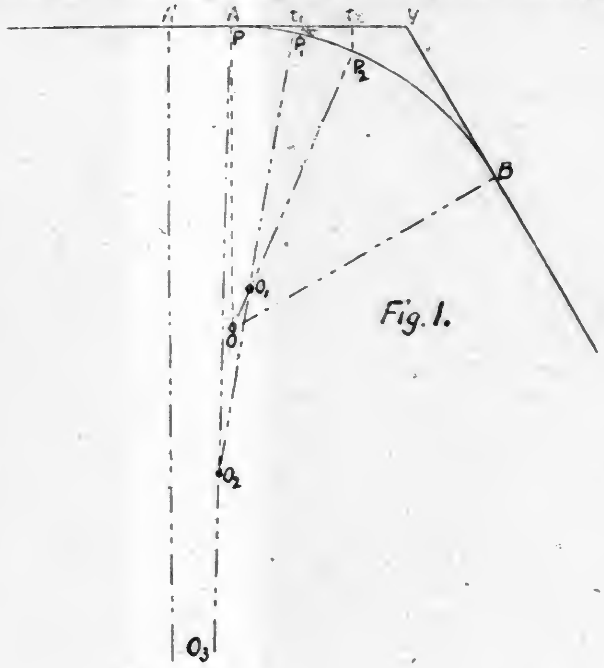
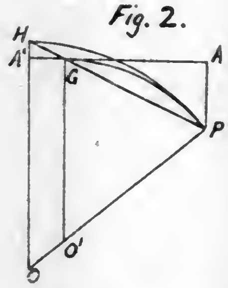


Fig. 1.

Fig. 2.



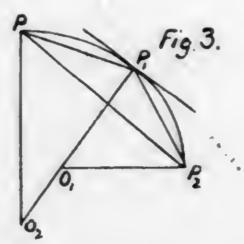


Fig. 3.

the same parts. We may run the curve from P to G, the deflection angle at P being, of course, the same as for the curve $P\ H$, namely, $\frac{1}{12}D$, the angle at O' being equal to the angle at O—that is, to $\frac{1}{6}D$. The chord $P\ G$ being less than $P\ H$ and the radius $P\ O'$ less than $P\ O$, the degree of the branch $P\ G$ is greater than that of $P\ H$, viz., $\frac{1}{6}D$. Knowing $A'\ H$, $P\ A$, and $H\ P = c = 100$ (say), $H\ G$ or $G\ P$ is easily found by similar triangles ; but it is not necessary to consider them. Of course the curve ends at A' instead of at G, which has no effect except to slightly lengthen and flatten the curve $P\ G$, making, to that extent, a transition curve of it.

To lay out the curve, suppose $A\ K\ P_2$ to be located. Then, since at P_2 the deflection for the curve $A\ K\ P_2$ is $\frac{1}{2}D$, and the deflection for the curve $A\ P_1\ P_2$ is $\frac{1}{2}(\frac{7}{6}D)$, the difference is equal to $\frac{1}{12}D$. P_1 is therefore inside of K a distance equal to $c \sin. \frac{1}{12}D$. Moreover, by the first assumption the chords $P\ P_1$ and $A\ K$ are parallel, therefore P is likewise inside of A a distance equal to $c \sin. \frac{1}{12}D$. Set P and P_1, therefore, each at a distance c sin.

$\frac{1}{12} D$, from A and K respectively, and A' on the tangent $A\ V$ and a chain from A.

Example 1. It is required to substitute a transition curve three chains in length in place of two chains of a 5° curve. We have $\frac{1}{12} D = 25'$ and $100 \sin. 25' = .727$. Set P and P_1 .727 of a foot inside of A and K and A' on the tangent one chain from P.

Example 2. To replace four chains of a 7° curve with a transition curve six chains in length : $\frac{1}{12} D = 35'$. Let $P_2 P_1 = P_1 P = P A = 2$ chains. Then $K P_1 = A P = 200 \sin. 35' = 2.036$ ft. This gives the position of P_1, P and A', and the intermediate stations can be set by middle ordinates at a distance 6.1 ft. from the middle of the chords.

To lay out a transition curve with the insrument : We observe that the chords $P P_1$ and $P_1 P_2$, in fig. 3, being perpendicular to the radii bisecting them, the angle between either chord and the prolongation of the other is equal to half the sum of the central angles O_1 and O_2 or to $\frac{1}{2} (\frac{7}{6} D + \frac{4}{6} D) = \frac{11}{12} D$. But the angles at P and P_2 are equal, and therefore either is equal to $\frac{11}{24} D$. Set the instrument at P_2, therefore, and turn off from the tangent $\frac{1}{2} \times \frac{7}{6} D = \frac{7}{12} D$ and set P_1 ; then an additional angle of $\frac{11}{24} D$ or a total angle of $(\frac{7}{12} + \frac{11}{24}) D = \frac{25}{24} D$ and set P.

In this connection it may be stated that other convenient transition curves may be found having different relations with the original curve than those above set forth. The method explained is perfectly general, applying readily to a transition curve ending at a given point on a parallel tangent. To vary the position of the end of the curve, it is only necessary to change the relative lengths of the branches of the transition curve. Transition curves, just as required in any case, can be found without any computation whatever. This subject will be fully treated in the "Engineer's Field Book," which has been in course of preparation by the writer for some years and is far advanced.

P. H. PHILBRICK,
Chief Engineer Kansas City, Watkins & Gulf Railroad.

To the Editor of the Railroad and Engineering Journal:

THAT the use of easement curves in railroad practice is desirable is admitted by most engineers. But it is a singular fact that those who advocate their introduction are frequently denounced as mere theorists by those who are unwilling to take the trouble to use them. Others condemn the use of the easement curves on the ground that it is impossible to retrace them after the original points are lost. In this connection I shall introduce an extract from a letter which recently appeared in the *Railroad Gazette* over the signature of Mr. William H. Brown, Chief Engineer of the Pennsylvania Railroad Company, as follows, viz. : "The elastic curve theory is all very nice in an office or college class-room, but I will venture to say that the people who are so enthusiastic in regard to this matter could not turn the curve twice in the same place on the ground." Now this may apply to instances where the subject has been treated from a purely theoretical standpoint, but I am one of those enthusiasts who believe that the subject admits of a simple and practical solution. I therefore have no hesitancy in submitting the table for spiralizing curves used on this road, together with diagram and explanation, and will venture to say that no competent transitman will meet with any difficulty in applying the same in the field. Neither will any competent transitman have any difficulty in retracing the curves as originally run, even if the original points be lost. Mr. Brown, in the letter referred to, advocates the use of 30-minute curves at the ends of all curves to ease the shock of trains at the tangent points, giving as his reason that while a curve of this kind answers every purpose, it "can be retraced by any person who can run a transit, even if the point of tangent is lost." I am unwilling to admit that this method of easement "answers every purpose," for I cannot see how a 30-minute curve compounding abruptly into a curve of shorter radius can dispose of the shock so effectually as the spiral curve. The method of spiralizing curves explained in the table has given excellent satisfaction wherever used, and I can see no objection to its use from either a theoretical or practical standpoint. It may be stated that shorter chords may be used if deemed advisable, or on account of sharp curves or short tangents.

FRANKLIN RIFFLE,
Chief Engineer Oregon & Washington Territory Railroad.

TABLE FOR SPIRALIZING CURVES.

TABLE OF DEFLECTIONS, P.S' TO P.T. CHORD = 30 FT.

D	1.	2	3	4	5	6	7	8	9	10	
1	06'	03'									
2	15'	24'	12'								
3	24'	42'	54'	27'							
4	33'	1°00'	1°21'	1°36'	48'						
5	42'	1°18'	1°48	2°12°	2°30'	1°15'					
6	51'	1°36'	2°15'	2°48'	3°15'	3°36'	1°48'				
7	1°00'	1°54'	2°42'	3°24'	4°00'	4°30'	4°54'	2°27'			
8	1°09'	2°12'	3°09'	4°00'	4°45'	5°24'	5°57'	6°24'	3°12'		
9	1°18'	2°30'	3°36'	4°36'	5°30'	6°18'	7°00'	7°36'	8°06'	4°03'	
10	1°27'	2°48'	4°03'	5°12'	6°15'	7°12'	8°03'	8°48'	9°27'	10°00'	5°

Deflections in digonal column are used in running Spiral from P.S. to P.C.

EXPLANATION OF TABLE.

Look in Column D for ° of curve; the first deflection on that line will be the deflection from Tangent for Chord point 1; the second for point 2, and so on until the number of points set will = D.

The last one will be the P. T.

TO CONNECT TWO TANGENTS WITH A CURVE, USING SPIRALS.— Set instrument at the P. I. and measure angle. Take Tangent corresponding to this angle from table of tangents to 1° curve. Divide by D (= degree of curve); to quotient add correction in column C, and measure this distance along each tangent to set P.S. & P.T. Move instrument to P.S. and to set any point on Spiral we have $(z^2 + 3')$ = deflection from Tangent. To set P.C. turn from Tangent $\frac{\Delta}{3}$. To turn Tangent at P.C., backsight on P.S. and turn $\frac{2\Delta}{3}$, calculate deflections for shortened radius, and put in Circular Curve. Central Δ of Circular Curve $= I - 2\Delta$. Move instrument to P.S'. and to set any point on Spiral we have $(D \times 9z - 3z^2)$ = Deflection in minutes from Tangent at P.S'. to any point on Spiral. The last deflection will be $\frac{2\Delta}{3}$. Move instrument to P.T. and backsight on P.S'., turn $\frac{\Delta}{3}$ and instrument will indicate succeeding Tangent.

SPIRAL TABLE.— LENGTH OF STANDARD SUB-CHORD = 30 FT.

D.	l.	S.	N.	Δ.	C.	Co-Ordinates.		Long Chords.	Radius.	D.
1	30'	.01'	1	09'	15.00'	.026	30.000	30.000	5,729.64	1
2	60'	.05'	2	36'	30.00'	.209	59.999	60.000	2,864.88	2
3	90'	.18'	3	1°21'	45.00'	.706	89.995	90.000	1,909.90	3
4	120'	.42'	4	2°24'	60.00'	1.674	119.979	119.990	1,432.27	4
5	150'	.82'	5	3°45'	75.04'	3.270	149.936	149.970	1,145.46	5
6	180'	1.41'	6	5°24'	90.08'	5.650	179.841	179.930	953.96	6
7	210'	2.25'	7	7°21'	105.18'	8.968	209.657	209.740	816.77	7
8	240'	3.34'	8	9°36'	120.35'	13.376	239.331	239.627	713.44	8
9	270'	4.77'	9	12°09'	135.67'	19.023	268.795	269.470	632.50	9
10	300'	6.54'	10	15°00'	151.14'	26.052	297.960	299.110	567.15	10

Let D = degree of Circular Curve.
" l = Length of Spiral.
" I = Intersection Angle.
" S = Shift of Circular Curve.
" C = amount to be added to Tangent to set P.S. or P.T. from P.I.

Let Δ = Cent. angle of Spiral.
" Z = No. of any Chord point.
" N = No. of chords in Spiral.
Length of Standard Chord = 30'

$\Delta = (9 D^2)$ $S = \frac{82^2 D}{1,100,000}$

Length of Spiral $= D \times 30' = l$.

Ex. Secant of spiralized curve = Ex. Secant of Circular Curves + S.

Let the Chord points be numbered from P.S. to P.C., calling P.S. 0, and from P.S'. to P.C., calling P.S'. 0.

R = Radius of Circular Curve. $R - S = R'$
R' = " " Spiralized Curve.

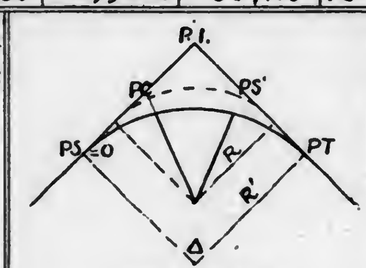


DIAGRAM.

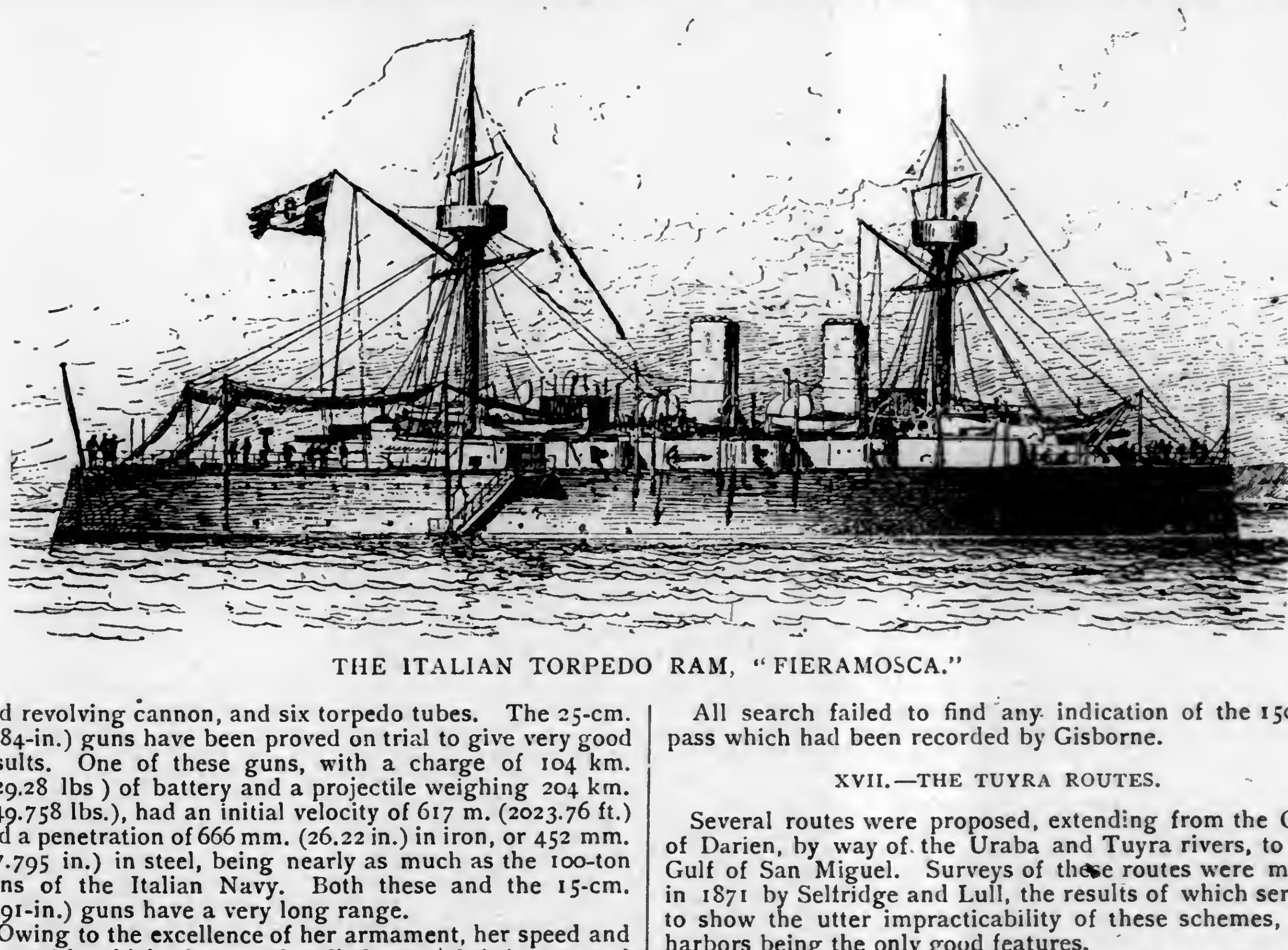
THE LATEST ITALIAN CRUISER.

THE latest addition to the Italian Navy is the *Fieramosca*, which is classed as a "torpedo ram," and which has been recently completed, the plans having been prepared under the direction of Commandante Vigna. The accompanying illustration, from *Le Yacht*, is a general view of the vessel.

The *Fieramosca* is 88.40 m. (289 95 ft.) in length; 13.20 m. (43.296 ft.) in width; has an extreme draft of 5.90 m. (19.35 ft.) and a displacement of 3,745 tons. She has two screws, each driven by a separate engine, and on the trial trip obtained a speed of 18.6 knots per hour, the engines developing 7,500 H.P. The hull is entirely of steel, and the machinery and magazines are protected by a heavy armored deck. The coal capacity of the bunkers is 590 tons.

The main battery includes two 25-cm. (9 84-in.) guns, weighing 25 tons, each mounted in pivot, one forward and the other aft, and six 15-cm. (5.90-in.) guns mounted in draw side. There is a secondary battery of machine guns and revolving cannon, and six torpedo tubes. The 25-cm. (9.84-in.) guns have been proved on trial to give very good results. One of these guns, with a charge of 104 km. (229.28 lbs) of battery and a projectile weighing 204 km. (449.758 lbs.), had an initial velocity of 617 m. (2023.76 ft.) and a penetration of 666 mm. (26.22 in.) in iron, or 452 mm. (17.795 in.) in steel, being nearly as much as the 100-ton guns of the Italian Navy. Both these and the 15-cm. (5.91-in.) guns have a very long range.

Owing to the excellence of her armament, her speed and ease with which she was handled on trial, it is expected that this ship will be very formidable in action—more so, perhaps, than some of the very heavy battle-ships for which the Italians have shown a preference heretofore.



THE ITALIAN TORPEDO RAM, "FIERAMOSCA."

INTEROCEANIC COMMUNICATION BY WAY OF THE AMERICAN ISTHMUS.

By LIEUTENANT HENRY H. BARROLL, U.S.N.

(*Continued from page* 206.)

XV.—THE ISTHMUS OF DARIEN.

THE Isthmus of Darien, situated south of the Isthmus of Panama, has long been regarded as the most prominent section for canal construction.

Notwithstanding the failure of the early attempts under Mr. Kelley and others, the United States Government has paid the closest attention to the examination of this section of the dividing ridge; and it was not until every ravine had been examined, each stream inspected, from its mouth till its waters were lost in the mountain streams, that the Canal Commissioners were satisfied with the examination.

XVI.—THE CALEDONIA BAY—SAN MIGUEL ROUTE.

The numerous early explorations of this route have been alluded to. After the United States Government commenced systematic surveys, the Isthmus of Darien was again explored, in 1870–71–73, by Captain Thomas O. Selfridge, U. S. N.

With regard to this line, two routes were here considered: one from Caledonia Bay, by way of the Savana River, to the Gulf of San Miguel; the other by way of the Sassardi and Morti rivers.

Selfridge's surveys showed for the former a lowest divide of 1,000 ft., with insufficient water for lockage; for the latter a line of levels showed that the Morti River itself, when first struck, had an elevation of over 300 ft.

All search failed to find any indication of the 150-ft. pass which had been recorded by Gisborne.

XVII.—THE TUYRA ROUTES.

Several routes were proposed, extending from the Gulf of Darien, by way of the Uraba and Tuyra rivers, to the Gulf of San Miguel. Surveys of these routes were made in 1871 by Selfridge and Lull, the results of which served to show the utter impracticability of these schemes, the harbors being the only good features.

The length of actual canal here would be 55 miles; and its cost, based upon a system of lockage, with a summit level of 160 ft., would exceed $250,000,000.

XVIII.—THE TRUANDO-ATRATO ROUTE.

This scheme contemplated a canal without locks, the western section of the canal being supplied with water from the Atrato River.

The initial point of the canal, which was also its summit level, was a point on the Atrato River, 32 ft. above the sea-level. It was proposed at this point to divert a portion of the Atrato River through a tunnel 12,250 ft. in length, passing underneath the dividing ridge and striking the Chuparador, proceeding by that river and the Parachuchichi to the Pacific.

Notwithstanding the complicated nature of a canal by this route, its estimated cost was only $134,450,000, and it for some time held the attention of the Canal Commissioners.

XIX.—THE ATRATO-NAPIPI ROUTE.

This route contemplated starting from the Gulf of Darien, ascending the Atrato River for some 140 miles, thence by a lock-canal and tunnel to Chiri Chiri Bay on the Pacific.

Several surveys were made here, in 1870–71–73, by Captain Selfridge, the projector of the route, and later, in 1875, a survey was made by the late Lieutenant Frederick Collins, U. S. N., who located the entire canal line. This route was also presented to the Paris Conference for their consideration, but was not successful in receiving the support of that body, notwithstanding the fact that careful estimates had placed the probable cost of its construction at less than $100,000,000.

XX.—OTHER ROUTES BY WAY OF THE ATRATO.

All other routes which contemplated using the Atrato River were definitely shown to be inferior to the Atrato-Napipi route, which, as finally projected by Selfridge, was clearly shown to be the most practicable, the least expensive, and affording the most natural advantages of all of the "Tunnel Routes." The other routes in this vicinity, after the projection of the Napipi route, were definitely abandoned.

There are many who still believe that a tunnel route is practicable; while others assert that these vast tunnels would, in this climate, become pest-holes, reeking with all forms of disease.

XXI.—THE PANAMA CANAL COMPANY.

The antecedents which led to the formation of the Panama Canal Company require explanation.

In October, 1876, a Society which had been lately formed in Paris, and which styled itself the "Société Internationale du Canal Interoceanique," authorized Lieutenant L. N.-B. Wyse, of the French Navy, to proceed to Central America, and make explorations for a canal route.

Notwithstanding the title of this Society, it was simply a speculative company, of which General Turr was President, and the directing spirit of which was M. de Lesseps.

Lieutenant Wyse was instructed to examine the route from the Gulf of Uraba (Darien) to the Gulf of San Miguel, by way of the Atrato, Carcarica and Paya rivers; and in case of difficulties presented by this line, to explore "any line that seemed feasible to the south and east of the line joining Capes Tiburon and Garachine."

The reason for this instruction may have been that all territory immediately to the north of this line was included in the grant to the Panama Railroad Company. The right of way through this would have to be purchased, and it would therefore seem that Lieutenant Wyse was not so much to seek the *best line* as the best line in a territory where the "Société" could secure a concession and profit by its sale.

These instructions were submitted to and approved by M. de Lesseps.

The expedition under Lieutenant Wyse was composed of 10 engineers and seven or eight assistants. Starting on the Pacific, they made, during a period of four months, in 1876–77, explorations over this route, during which explorations no part of the expedition penetrated to the Atlantic Coast.

Two canals were nevertheless proposed and elaborated. One, a lock-canal, by way of the Tuyra and Caquerri rivers, and another, a tide-level canal, by way of the Tupisa, Tiati and Acanti-Tolo rivers.

The latter route was explored under the personal supervision of Lieutenant Wyse as far as its junction with the Tiati, or only half of the distance which it was proposed to canalize. The remainder of the line was not even reconnoitered; yet M. Wyse felt competent to estimate to within 10 per cent. the cost of a canal here.

In October, 1877, M. Wyse and party again returned, under orders from the same Société, to make further surveys upon this and other possible routes. M. Wyse's special mission, this time, seems to have been the negotiation with the Colombian Government concerning concessions, and in his absence the surveys were under the charge of M. Reclus.

They made surveys across the San Blas-Bayamo route, and also explored several other river valleys. Between April 3 and April 20, 1878, the party ran a line of survey along the route of the Panama Railroad, with a view to the construction of a tide-level tunnel canal. The survey consisted of level lines and cross-sections continued up to the extremities of the proposed tunnel, and did not continue over the divide.

Shortly after this survey of the Panama line had been concluded, M. Wyse returned from Bogota to Panama, having been successful in securing from the Colombian Government a concession covering the whole of the territory of the United States of Colombia, which, therefore, gave the Société exclusive right of way over all of the proposed routes except those of Nicaragua and Tehuantepec; while it was well known, by this time, that a canal by way of the Isthmus of Tehuantepec was impossible.

M. Wyse left Panama for Greytown, Nicaragua, examined that harbor, and had some correspondence with the President of the Republic of Nicaragua, but was evidently not successful in getting control of this canal route for the company of which he was the agent.

Plans were made for canals of the following dimensions:

Breadth at bottom	20 meters.
Breadth at 3 meters from the bottom	26 meters.
Breadth at water-surface, according to nature of the soil	32 to 50 meters.
Depth at mean low tide	8.5 meters.
Tunnel:	
Breadth at bottom	20 meters.
Breadth at water-surface	24 meters.
Height above level of the water	34 meters.

With these dimensions, and the data procured from the Wyse surveys of 1876–77–78, estimates were made for the following canal routes, 25 per cent. being allowed for contingencies:

1. A lock-canal *via* the Atrato, Caquerri and Tuyra rivers: Length, 128 kilometers; height of summit level, 50 meters; locks, Atlantic side, 10; locks, Pacific side, 12. The summit level to be a lake formed by dams across ravines in the valley of the Tuyra. Estimated cost, from 650,000,000 to 700,000,000 francs.
2. A tide-level tunnel canal *via* the Tupisa, Tiati and Acanti-Tolo rivers: Length, including tunnel, 74 kilometers; length of tunnel, 17 kilometers; estimated cost, about 600,000,000 francs.
3. San Blas tide-level tunnel canal *via* the Bayamo and other streams: Length, 41.5 kilometers; length of tunnel, 15.8 kilometers; estimated cost, about 475,000,000 francs.
4. Panama tide-level tunnel canal *via* Chagres and Rio Grande rivers: Length, 73.2 kilometers; length of tunnel, 7,720 meters; estimated cost, 475,000,000 francs.

XXII.—THE PARIS CONFERENCE.

In 1879 an International Conference was held in Paris, with a view to discussing the question of an Interoceanic Canal.

The Conference was composed of 136 members, of whom 74 were French, the other 62 being divided among all other nationalities; the United States being represented by 11 members and the British Empire by six. Among the delegates from the United States were Admiral Daniel Ammen, U. S. N., Commander Thomas O. Selfridge, U. S. N., and Civil Engineer A. G. Menocal, U. S. N.

These three persons were then, and probably are now, the most competent authorities on this subject, each of them having been for years engaged upon surveys of the American Isthmus.

It was from the first plainly to be seen that the majority of the Conference were prejudiced in favor of M. de Lesseps and the Société Internationale, of which General Turr was the President. M. de Lesseps had advised the explorations which had been made by the Society. He was made the President of the Paris Conference, and it was found that he had previously mapped out the work of that body before it had assembled.

Five committees were formed, and one of these, known as the "Technical" Committee, and composed of 42 members, afterward increased to 45 members, was vested with the responsibility of deciding the location of the canal.

Of this committee only two were Americans—only two members from the country through which the proposed canal was to be built!

M. Wyse presented before this Conference a map made from his examinations between April 3 and April 20, 1878, and which was substantially the same as that made by G. M. Totten, the constructor of the Panama Railroad; and this, the "Wyse-Reclus" Canal, first proposed, was that previously mentioned in this article as a tide-level tunnel canal between Aspinwall and Panama.

Mr. Menocal called attention to the immense floods of the Chagres River, and the damage they would do to a tide-level canal.

Sir John Hawkshaw, one of England's ablest engineers, drew attention to the fact that a tide-level canal would receive and must provide for the whole drainage of the district traversed; also that, according to Mr. Menocal's estimates, the volume of the Chagres in the time of flood would much more than fill the proposed tunnel.

Such vital objections were raised to this scheme that it was finally withdrawn, and another scheme introduced by MM. Wyse and Reclus, for a canal between Aspinwall and Panama, but doing away with the tunnel altogether, and altering the route.

The several proposed routes were finally reduced to the following:

First, Lock-canals, comprising:

1. The Nicaragua scheme of Menocal;
2. The Nicaragua scheme of Blanchet;
3. The Panama scheme of Menocal (Lull's route);
4. The Panama scheme of Wyse.

Second, Tide-level canals, comprising:

1. The Panama open-air scheme of MM. Wyse and Reclus;
2. The San Blas scheme of F. M. Kelley;
3. The San Blas scheme of Selfridge;
4. The San Blas scheme of Wyse;
5. The Atrato-Napipi scheme of Selfridge.

All others were rejected.

It must be borne in mind that the Société Internationale had failed to secure a concession of the route *via* Lake Nicaragua; also that Mr. Menocal's scheme at Panama was for a lock-canal, while M. Wyse's scheme at the same point was for a tide-level canal.

Before the committee of 45 members charged with deciding the location of the canal was presented, on May 28, 1879, the following proposition to be voted upon:

"That the committee, from the point of view for which it was instituted, is of the opinion that it should recommend to the Conference the adoption of a tide-level, maritime canal, from the Gulf of Colon, or of Limon, to the Bay of Panama."

There was violent opposition to this, and it was finally remodeled to read:

"The Technical Committee believe that the interoceanic canal should be constructed between Colon and Panama."

This was passed by a vote of 20, 16 members being absent and 9 not voting.

The next resolution, being that the Committee recommended a tide-level canal, was carried by a vote of 16.

The action of this Technical Committee, when presented before the Conference, was sustained by 78 members, 19 of whom were engineers.

On May 29 this peculiar assembly was dissolved.

The Panama Canal Company was now formed, and then followed that strange financial proceeding by which M. de Lesseps attempted to gain the money for the completion of this gigantic work.

Interest was guaranteed on the dormant capital invested during the construction of the canal.

The Company's bonds were sold, bearing interest payable with a part of the money for which they sold, and this money received as interest could be used to purchase other bonds, which bore interest payable from the money received from these last-purchased bonds, etc.

The enthusiastic character of the French people sufficed to enable the Company to raise nearly $400,000,000—over four times the amount that Commander Lull computed as the probable cost of a canal over this route.

After working for some months and seeing the impracticability of constructing a tide-level canal, M. de Lesseps changed the plan, and the last work done upon the Panama Canal was with the view of making a lock-canal.

XXIII.—COMPARISON OF THE DARIEN, PANAMA AND NICARAGUA ROUTES.

It is now seen that the numerous proposed routes have been by careful surveys reduced to three lines, each of which has some characteristic separating it widely from the others:

1. The Atrato-Napipi, with its fine river Atrato and comparatively short canal-line, and three miles of tunnel;
2. The Panama Route, with short distance from ocean to ocean, yet with the unruly Chagres River occupying the only possible line of canal;
3. The Nicaragua Route, with a low profile and with Lake Nicaragua at its summit level, yet with no natural harbors.

Over each of these routes a canal-line has been located, and estimates computed of its probable cost. A brief review of the dimensions of canal prisms, scales of prices used, and estimates of cost, will allow a graphic comparison of the advantages and disadvantages of each route.

XXIV.—THE ATRATO-NAPIPI ROUTE.

The different surveys of this route by the parties under the direction of Commander Selfridge had shown this to be one of the most favorable localities.

Lieutenant Frederick Collins, U. S. N., made, in 1875, an extended survey here, locating the entire canal-line from the Atrato River to the Pacific. From the data of this survey computations were made for the cost of a canal of the following dimensions:

Total length of canal	30.24 miles.
Width at bottom	72 ft.
Width at water-surface in rock	98 ft.
Width at water-surface in earth	150 ft.
Depth, 26 ft.; in tunnel	27 ft.
Slope of sides in earth	1½ base to 1 perpendicular.
Slope of sides in rock below water	1 base to 2 perpendicular.
Slope of sides in rock above water	¼ base to 1 perpendicular.
Embankments:	
Width at top	9 ft.
Interior slope	1½ base to 1 perpendicular.
Exterior slope	2 base to 1 perpendicular.
Width of "bench" at 10 ft. above water-surface	9 ft.
Length of embankments	14 miles.
Locks:	
Width	60 ft.
Length between miter sills	400 ft.
Tunnel:	
Length	3½ miles.
Width at water-surface	70 ft.
Height from bottom of canal to crown of arch	113 ft.
Depth	27 ft.

There were two forms of tunnel proposed by Lieutenant Collins. The first, for solid rock: To be trapezoidal in section, with segmental arch of 120°; the crown of the arch to be 86 ft. above the water-surface; the width at the water-surface to be 70 ft.; depth, 27 ft., and sides below water to be battered 1 to 20. The arch to be formed of masonry 5 ft. thick at the spring and 3 ft. thick at the crown, and backed by concrete.

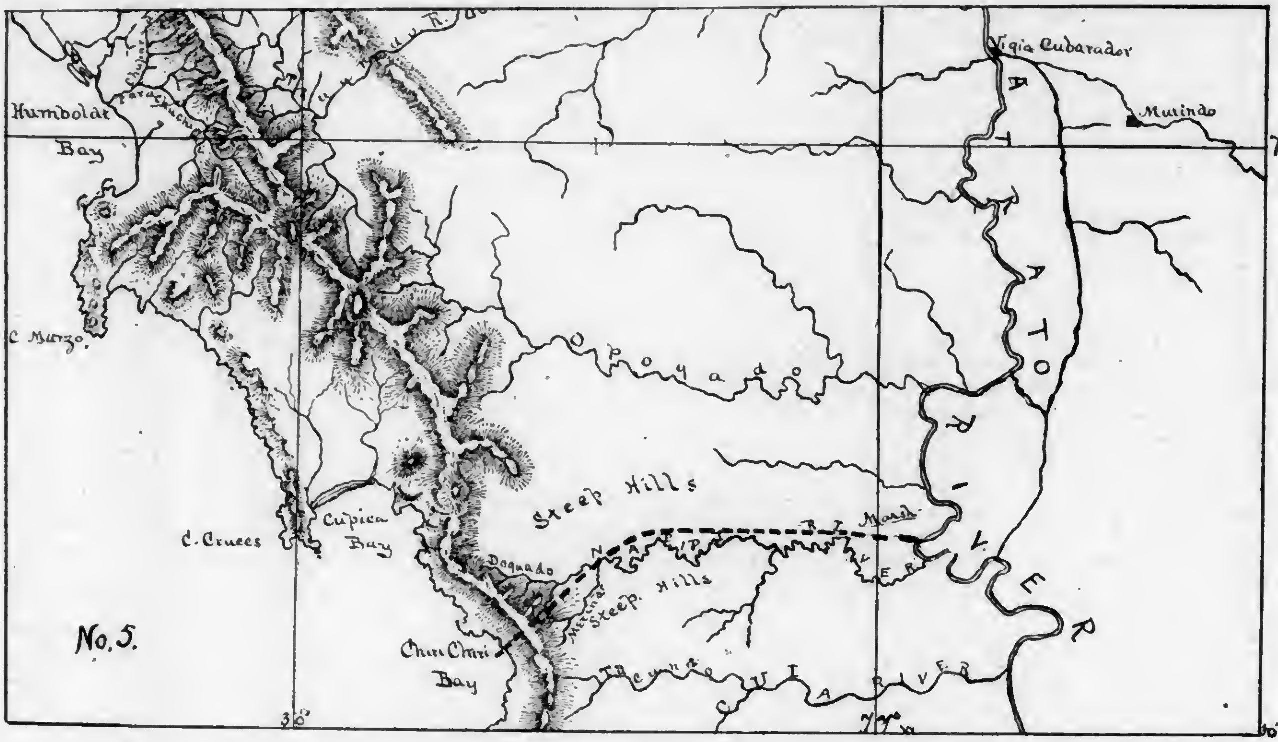
The second, in unsafe or badly seamed rock: The tunnel to be elliptical in section, with conjugate diameter of 70 ft. at the water-surface, and semi-transverse diameter of 86 ft. above water-surface; the section to be continued below, so as to give 27 ft. of water. In this section the arched lining was designed to spring from the water-surface with a thickness of 5 ft., and diminishing to 3 ft. at the crown.

Each section gave 1,846 sq. ft. area of water space.

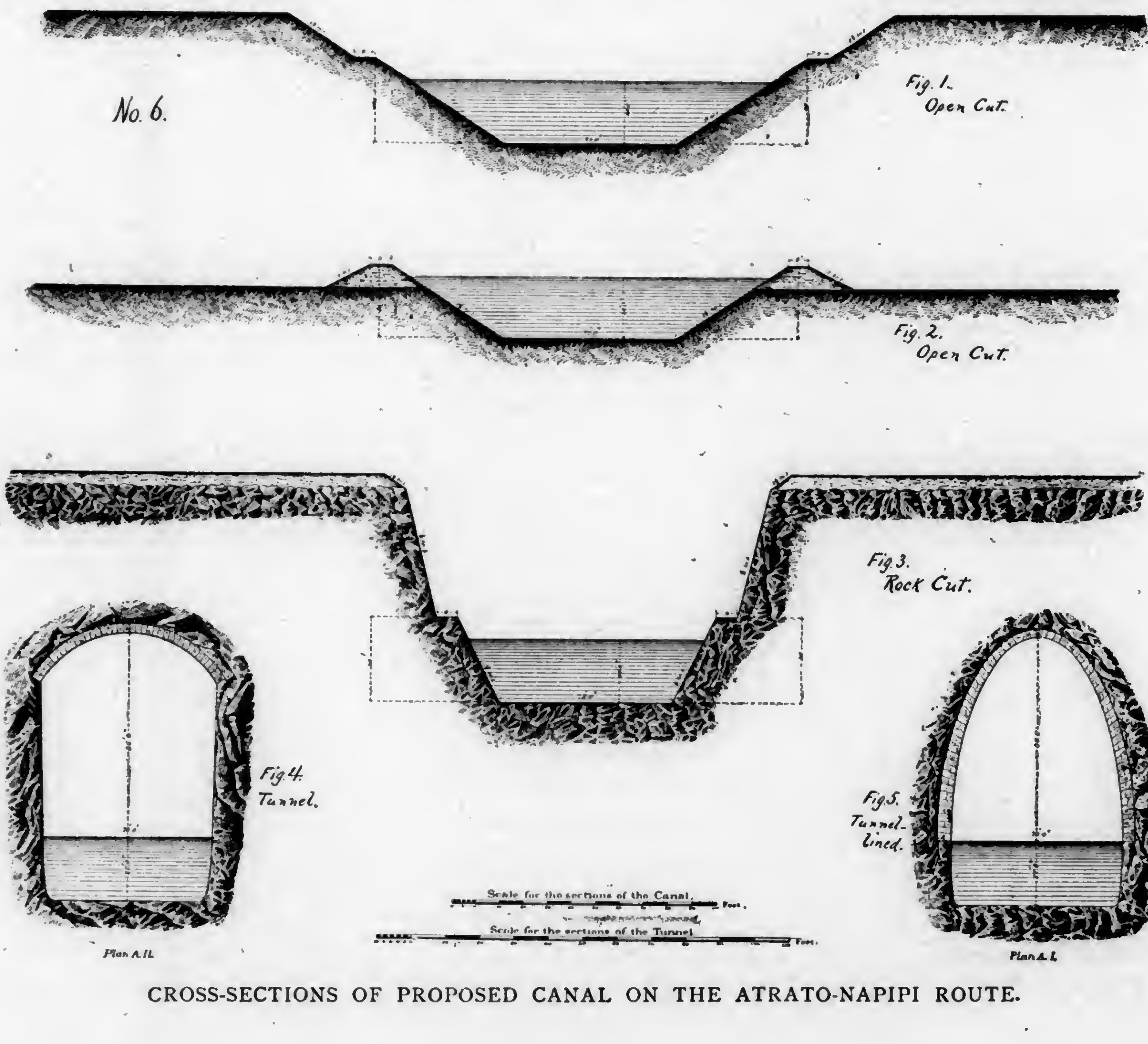
The Trapezoidal plan required: Excavation, 5,279,843 cubic yards; masonry, 203,498 cubic yards; estimated cost of tunnel, $32,479,120.

The Elliptical plan required: Excavation, 5,102,865 cubic yards; masonry, 682,993 cubic yards; estimated cost of tunnel, $40,960,272.

In the final computation of the canal's cost a modified



MAP OF PROPOSED CANAL ON THE ATRATO-NAPIPI ROUTE.



CROSS-SECTIONS OF PROPOSED CANAL ON THE ATRATO-NAPIPI ROUTE.

form of tunnel was considered, being only 60 ft. in width, and the cost of which, taking the mean between the two plans, was $33,241,923.

The water supply of the Napipi and Doguado rivers was further increased by that of the Cuia River. The feeder canal for this was 3½ miles in length, having a fall of 14 ft. in that distance, passing through a tunnel of 9,230 ft. and open cutting of 7,720 ft.

The estimated cost of the feeder canal was $548,726. The daily water supply at lowest stage, from the Napipi, Doguado and Cuia rivers, was found by cross-sections and current meter observations to be 24,000,000 cubic feet.

The following prices were used in computing the cost of this canal: Excavation in earth, 30 to 35 cents per cubic yard; excavation in rock, $1.25 to $1.50 per cubic yard; excavation in tunnel, $5.35 per cubic yard; arched lining of tunnel, $20 per cubic yard; masonry, $15 per cubic yard; dredging, 50 cents per cubic yard; hydraulic concrete, $7 to $8 per cubic yard.

The estimated cost of the canal was:

Excavation and embankment	$28,697,398
Tunnel (as modified, to width of 60 ft.)	33,241,923
Locks	5,049,214
Culverts	3,031,405
Side drains	2,449,953
Diversion of rivers	1,670,159
Dam for crossing Napipi	616,057
Breakwater at Chiri Chiri	2,163,000
Aqueduct	548,726
Improvements, mouth of the Atrato	817,780
Lighthouses	60,000
Grubbing and clearing	191,900
	$78,557,515
Add 25 per cent. for contingencies	19,636,879
Total estimated cost	$98,194,394

The following advantages and disadvantages were enumerated by Lieutenant Collins in his report:

Advantages:

1. Shortness of the artificial channel required (30.24 miles).

2. Good harbors; that on the Atlantic is all that could be desired, while on the Pacific there is good holding-ground, and the region is seldom visited by violent gales.

3. The cutting being mainly in stiff rock or clays, the clay forms stable embankments, little liable to wash from rains or at the water-surface, and its impervious character prevents, in a great degree, loss by filtration or leaks.

4. The greater portion of the work to be performed lies in a healthy region for the tropics.

5. Abundance of good timber for construction.

6. Proximity of the heaviest work to the Pacific Coast, rendering transportation of labor, plant, and supplies comparatively inexpensive.

7. Absence of high winds along the canal-line.

8. Freedom from terrestrial convulsions of a nature likely to affect the permanency of the work.

9. Absence of large streams or of deep valleys to be crossed at a high elevation.

10. Friendly attitude of the inhabitants.

11. Fertility of the soil. Under proper management the country in the vicinity of the canal-line could be made to produce the greater part of the supplies required for the subsistence of the laborers.

Disadvantages:

1. The necessity of resorting to a tunnel, involving great expense in construction, uncertainty in estimates of cost, and a probable increase in the difficulties attending transit, especially for large ships.

2. The steep descent of the Pacific Slope, necessitating the grouping of a large number of locks, and thus increasing the liability of damage to the works.

3. Very heavy cuttings in the valley of the Doguado and Chiri Chiri rivers.

4. Limited water supply during the dry seasons.

5. Liability of damage to the works from sudden floods. It is believed that this contingency is well guarded against, but the liability of sudden and heavy floods, in a hilly country subject to torrential rains, cannot be overlooked.

6. Excessive rains, liable to wash away embankments, etc., while in the process of construction, and to interfere generally with the progress of the work.

7. The shortness and uncertainty of the yearly periods well suited to the work of construction.

8. Undeveloped state of the country, and scarcity of native labor.

9. Remoteness from the great commercial centers of the world.

In Plate No. 6 are given the proposed cross-sections for the canal by this route. Figs. 1 and 2 show earth cuttings; fig. 3, rock cutting; figs. 4 and 5, tunnel sections.

(TO BE CONTINUED.)

PRESERVING WOODEN PILES.

(Paper read before the Tacoma Society of Civil Engineers & Architects by Mr. Colin McIntosh.)

THE problem of protecting piling and timber in submarine structures against the ravages of the teredo and other marine insects has long been a vexed one, and numerous plans and experiments have been tried, a great many of which with only partial success. Before speaking of these experiments and plans, a description of the pests will not here be amiss. The following is a description of the teredo and its habits: The ship worm—*teredo navalis*—is a mollusk belonging to the tubiferous bivalves, and has been from time immemorial the subject of comment on account of its ravages. There are 24 species of the teredo, but the ship worm is the best known. The *teredo navalis* has a long and flexible body terminating in cutting shells or bits, and is enclosed, for the sake of its protection, in a hose-like shell which reaches from the inferior extremity to within a very short distance of what is known as the head. At that point the muscles come into play and work the cutters or bit edges and so drive into the timber, cutting a smooth, round hole. The teredo first appears in the egg, which is round like a mustard-seed and so small that a hundred of them could be enclosed by the shell of such seed. These eggs are laid at the beginning of the warm season and are deposited from time to time until cold weather sets in. A teredo will deposit from 1,000,000 to 3,000,000 eggs. The eggs hatch in the water and give out minute worms about 0.04 in. in length. They swim about for a short time in search of timber. They enter this by boring or cutting with their cutters, and the entrance is so small that it can be scarcely seen. The worm grows at the rate of 2 in. per month, and digs a hole to accommodate its increasing size. The length of the hole is therefore a guide to the length of the teredo, for it attaches its smaller end to the entrance of its burrow and pushes forward with the growth of its body. As it progresses it deposits a coating of lime upon the sides of its cell, the deposit growing thinner as the worm advances, being quite thick at the entrance.

The worm continues its progress for 12 or 18 months, propagates and dies. It reaches a length of about 10 in., although I have seen one 18¾ in. long, $\frac{1}{16}$ in. diameter of bits. It is remarkable with what accuracy the teredo avoids the burrow of its neighbor, coming within the thickness of a piece of tissue paper. As fine sawdust is found in the stomach of the teredo, it is natural to suppose that it subsists on the same.

It is known that the teredo cannot exist in muddy water, as piling from the Mississippi Sound has been examined after the annual floods, when the river water is very muddy, as the dead bodies of the worm have been found in these piles. Again, it is proven that they can exist for a short time in fresh water, as at Brisbane, Australia, it is forced to survive the annual recurring exposure to fresh water from the floods lasting from two to three months. The limnoria, a brother in mischief to the teredo, is a crustacea about the size of a grain of rice and of a darkish gray color. The front outline of the body is a long oval, though the head is large, round, and strongly defined. The general appearance is that of a wood louse. When disturbed or handled they roll up like a hedgehog. In San Francisco Bay these little creatures are very destructive to piling or timber in submarine structures.

They attack a pile about half-tide and swarm around in millions. They excavate little cells along the annular rings of growth, and while eating the wood for its albumen, make a sheltering place for protection against enemies and a place in which to breed. A pile that has been eaten off by limnoria resembles a piece of wood that has been beavered, except where knots appear; these the insect does not touch.

The plans adopted for protecting piles against these pests are numerous, the best known and most efficient being to creosote them, which is done by subjecting the pile, after being peeled, to two hours' steaming, 10 hours in a vacuum and 12 hours in a retort, in which the creosote is forced into the wood, taking the place of the sap, which has been withdrawn from the wood. From 10 to 12 lbs. of creosote to the cubic foot of wood is about the right charge. This is known to be effective against the ravages of the teredo. The only objection to this process is its first cost. It will not pay to creosote piles on this coast, owing to the low price of same compared with creosote. A creosoted pile, say 40 ft. in length, is worth on the Pacific Coast about $20. Covering piles with copper has been tried and with great success, but as it costs about the same as creosoting it is objectionable on that account.

Studding the exposed parts of the pile with copper tacks has been tried by the New York Harbor Commissioners with success, but as this method uses as much copper as the former and more labor is necessary to put it on, the objection is the same.

Mr. John Culver, an engineer of San Francisco, invented a process consisting of treating the pile in the following manner: First brush a poisonous composition over the peeled pile, which is allowed to dry; next coat the pile with asphaltum laid on at a great heat, after which canvas treated in asphaltum is wrapped around in spiral courses and fastened by copper wire, then another coat of asphaltum and the pile is ready for driving. This process costs about $5 for an average length pile, and has resisted the attack of the teredo in New York Harbor for a period of three years, being the time exposed. The latest plan that has been tried on the Pacific Coast is a covering or coating of Ventura asphalt, which is found in Ventura County, Cal. The piles are peeled, then coated with one or two coats of Ventura asphalt, each coat about ⅝ in. thick. The cost of preparing piles in this manner is about 24 cents per lineal foot. Piles thus prepared have been driven in San Francisco Bay and have been exposed to the attack of the limnoria and teredo for more than a year without any signs of destruction.

The plan adopted by the Northern Pacific Railroad for protecting the foundation of their coal bunker in Tacoma is worthy of mention. This plan consists of driving clusters of piles and encasing the same with wrought iron cylinders of metal ¼ in. thick, and filling in space between piles and cylinder with concrete. The writer believes that sand well packed in the cylinder would answer as well as concrete, for if the iron is eaten away by rust, the concrete is not of sufficient thickness to stand by itself and would readily fall away from the piles. This plan is very efficient.

Another plan tried by the Northern Pacific Railroad similar in design to the above, is in substituting wooden boxes in place of iron cylinders around each pile. This plan was not very effective, as the wood casing was soon eaten away and the concrete fell away from the piles; moreover, it can only be used where the piles are exposed between tides.

The writer tested a covering for piles prepared in the following manner: A section of peeled pile about 3 ft. long was coated with asphaltum and then rolled in sharp sand, and then another thin coat of asphaltum applied. This sample was exposed for a period of 14 months without any signs of destruction, but it was noticed that the asphaltum and sand covering commenced to peel off, leaving the wood exposed, therefore it was abandoned.

Another plan devised by the writer and Mr. Hopkins seems to be plausible, but has not been tried. This consists of slabbing the pile and then tacking on tarred paper on the core, then covering the tarred paper with the same slabs well spiked on. The slabs are not cut full length of the pile, but leave the end that enters the ground solid. The end that is struck by the hammer is to have the slabs removed for a length of 5 ft. or 6 ft., leaving a solid core to receive the blows and to allow for brooming.

In the discussion on this paper the opinion was expressed that the cost of coating a pile with Ventura asphalt had been placed too high, and that it would probably not exceed 12 cents per foot for piles of average size, in Washington or Oregon.

Inquiry was made regarding the old Dutch plan of closely driving long nails into the timber below water-line. The method was not indorsed by those present.

Wrapping the piles with tarred canvas or tarred paper and slabbing them was generally recognized as a cheap method and practicable. Sections of piles thus treated, which had been under water seven and eight years at San Francisco, were submitted. There were but two or three holes made by the teredo through either section.

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C.E.

(*Continued from page* 219)

CHAPTER XXV.

HOWE TRUSS DECK BRIDGES (*Continued*).

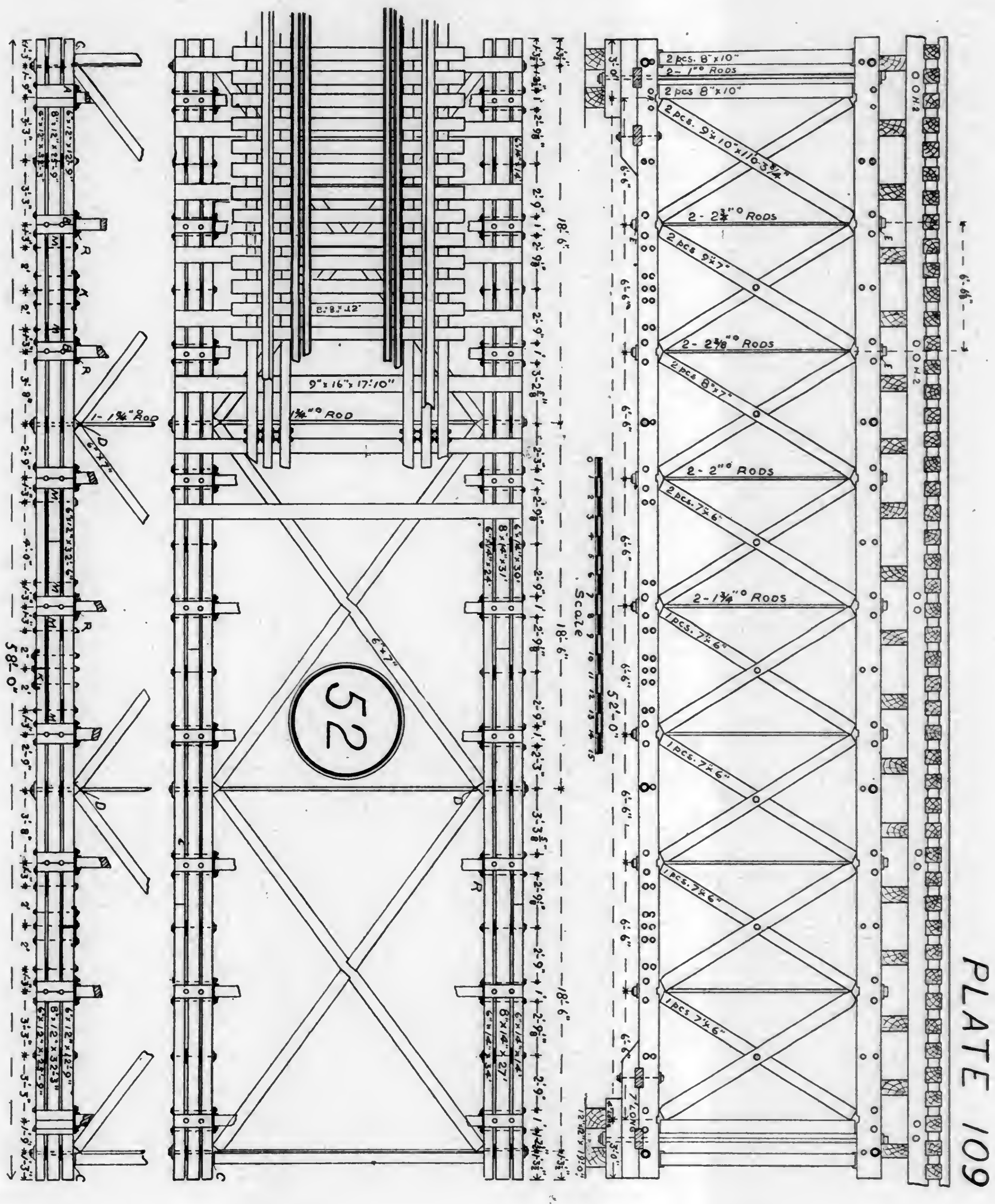
With the preceding chapter there were given plans for a bridge of 42 ft. span. With this chapter the plans are for a Howe truss deck bridge of 52 ft. span; Plate 109 giving an elevation and plans, while the details are shown on a larger scale in Plates 110 and 111.

As with the preceding plans, the construction and details of the bridge are shown very completely by the drawings and the accompanying bill of material, so that little

No. 45. Bill of Material for Howe Truss Deck Bridge, 52 Ft. Span. Plates 109, 110 and 111.

Timber.

No. of Pieces.	Description.	Size.	Length.
4	Top Chord.	6 in. × 14 in.	14 ft. 0 in.
2	" "	6 in. × 14 in.	30 ft. 0 in.
2	" "	6 in. × 14 in.	24 ft. 0 in.
2	" "	6 in. × 14 in.	34 ft. 0 in.
2	" "	8 in. × 14 in.	31 ft. 0 in.
2	" "	8 in. × 14 in.	27 ft. 0 in.
4	Bottom Chord.....	6 in. × 12 in.	12 ft. 9 in.
2	" "	6 in. × 12 in.	32 ft. 6 in.
2	" "	6 in. × 12 in.	32 ft. 3 in.
2	" "	6 in. × 12 in.	25 ft. 9 in.
2	" "	8 in. × 12 in.	25 ft. 9 in.
2	" "	8 in. × 12 in.	32 ft. 3 in.
8	Main Braces........	9 in. × 10 in.	11 ft. 3¾ in.
8	" "	9 in. × 7 in.	11 ft. 3¾ in.
8	" "	8 in. × 7 in.	11 ft. 3¾ in.
8	" "	7 in. × 6 in.	11 ft. 3¾ in.
16	Counters...........	7 in. × 6 in.	11 ft. 3¾ in.
16	End Posts.........	8 in. × 10 in.	9 ft. 10½ in.
12	Laterals.	6 in. × 7 in.	22 ft. 6¾ in.
4	"	6 in. × 7 in.	13 ft. 10½ in.
18	Internal............	6 in. × 7 in.	17 ft. 3 in.
8	Bolsters............	6 in. × 7 in.	7 ft. 0 in.
4	"	8 in. × 10 in.	7 ft. 0 in.
8	Bridge-seat.........	6 in. × 10 in.	4 ft. 0 in.
4	" "	8 in. × 10 in.	4 ft. 0 in.
4	Sills................	12 in. × 12 in.	18 ft. 0 in.
18	Floor-beams...	9 in. × 16 in.	17 ft. 10 in.
6	Track Stringers....	6 in. × 12 in.	58 ft. 0 in.
51	Ties................	8 in. × 8 in.	12 ft. 0 in.
2	Guards.	6 in. × 6 in.	58 ft. 0 in.
4	Plank..............	2 in. × 8 in.	58 ft. 0 in.
8	Blocks.............	2 in. × 8 in.	2 ft. 0 in.



Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	1 in.	14 ft. 6 in.	84	Int'l & splice	¾ in.	2 ft. 0 in.
8	"	2¾ in.	12 ft. 10 in.	20	Stringer b'lts	¾ in.	2 ft. 6 in.
8	"	2⅜ in.	12 ft. 10 in.	12	Bolster-b'lts	1⅛ in.	2 ft. 6 in.
8	"	2 in.	12 ft. 10 in.	72	Floor-bolts.	1¼ in.	3 ft. 0 in.
4	"	1¾ in.	12 ft. 10 in.	36	Tr. str'r b'ts	¾ in.	2 ft. 10 in.
8	Laterals.	1¾ in.	18 ft. 6 in.	34	Tie-bolts.	¾ in.	2 ft. 6 in.
48	Chord-bolts.	¾ in.	2 ft. 0¼ in.	18	Guard-bolts.	¾ in.	1 ft. 3 in.
16	Brace-bolts.	¾ in.	2 ft. 0¼ in.	32	Spikes.	⅜ in.	....

Castings.

Number: 8 of pattern *A*; 28 of *B*; 8 of *C*; 8 of *D*; 36 of *E*; 40 of *F*; 36 of *G*; 24 of *H3*; 40 of *H2*; 16 of *J4*; 600 of *J1*; 168 of *J2*; 3 of *K*; 10 of *L*; 10 of *M*; 5 of *P*; 36 of *R*; 8 of *S*.

or no further description is required. Some remarks on this design, however, will be made in later chapters.

In comparing these plans, the reader will perhaps find it convenient to refer back to the general remarks on Howe truss bridges given in Chapter XXII., in the JOURNAL for March, 1890.

(TO BE CONTINUED.)

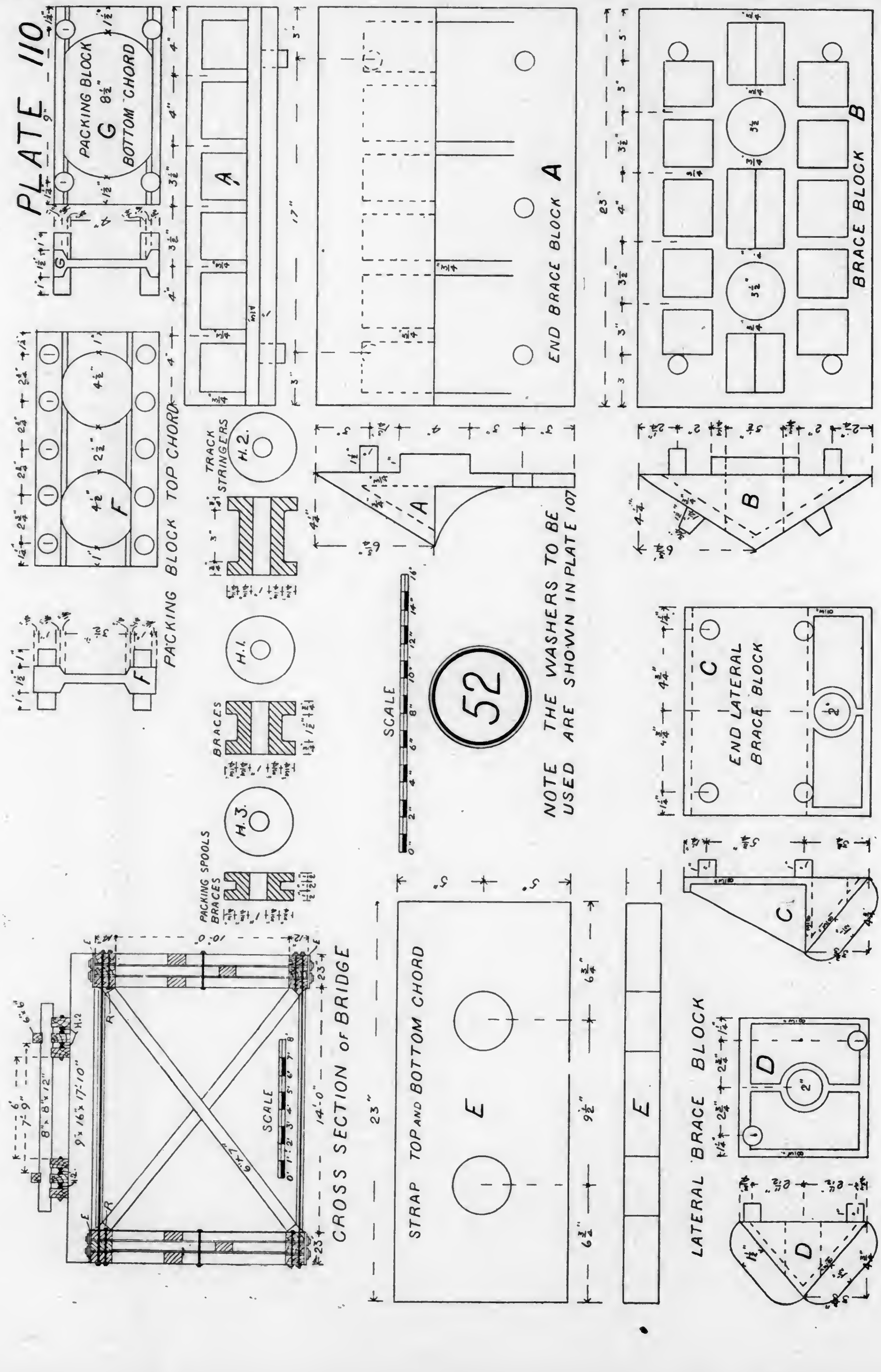


PLATE 110
PACKING BLOCK G BOTTOM CHORD
END BRACE BLOCK A
BRACE BLOCK B
PACKING BLOCK TOP CHORD
TRACK STRINGERS
H.2.
H.1.
H.3.
BRACES
PACKING SPOOLS BRACES
SCALE
52
NOTE THE WASHERS TO BE USED ARE SHOWN IN PLATE 107
END LATERAL BRACE BLOCK
CROSS SECTION OF BRIDGE
STRAP TOP AND BOTTOM CHORD
LATERAL BRACE BLOCK

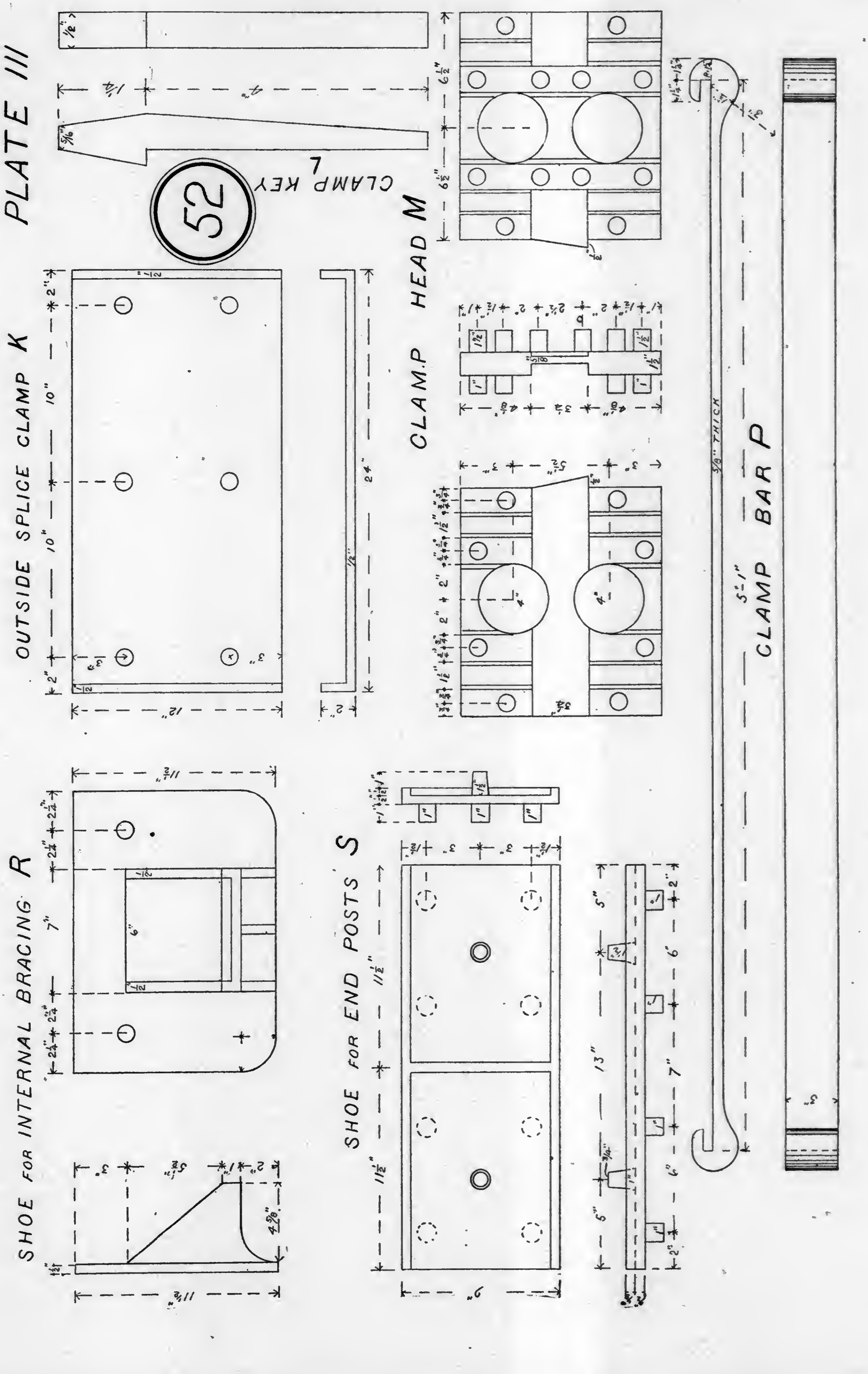


PLATE III
CLAMP KEY L
52
CLAMP HEAD M
OUTSIDE SPLICE CLAMP K
CLAMP BAR P
5/8" THICK
SHOE FOR INTERNAL BRACING R
SHOE FOR END POSTS S

THE FIRST SECTION OF THE GREAT SIBERIAN RAILROAD.

By A. Zdziarski, Engineer.

It may now be said with certainty that the construction of the great Siberian Railroad is only a question of time, since in the latter part of 1886 his Majesty, the Czar of Russia, on receiving a report from the Governor-General of East Siberia, Count A. G. Ignatieff, put upon it the following endorsement:

"*I have read so many reports of the Governors-General, and I am sorry to confess that the Government so far has done almost nothing to meet the needs of this rich but undeveloped country. And it is time, full time.*"

Of course the construction of so great a line, which will reach a length of about 10,000 versts (6,666 miles), measuring from St. Petersburg, cannot be begun without preliminary surveys and consultations, and therefore, in 1887, it was decided to begin the explorations. The work of laying out a programme for the preliminary surveys was entrusted to a committee of four ministers: The Minister of Roads and Communications, the Minister of War, the Minister of Finance, and the State Comptroller.

This Commission decided to order the survey of the following lines in Siberia:

1. From Tomsk through Achinsk, Krasnoyarsk and Kainsk to Irkutsk and to Lake Baikal, a distance of 1,130 miles.
2. From Posolski, on the shore of Lake Baikal, through Verkhne-Oudinsk, the Petrowski Works, and Nerchinsk to Sretensk, a distance of 730 miles.
3. From Vladivostok through Razdolnoe, Nikolske and Anuchino to Busse, a distance of 270 miles.

It will easily be seen from the map of Siberia that these three proposed lines connect the navigable water-ways of the country. The first, called the Central Siberian Railroad, would connect the river Obi with Lake Baikal; the second, called the Trans-Baikal Railroad, would connect Lake Baikal with the river Amour, and the third, called the Oussouri Railroad, would connect the Oussouri, a tributary of the Amour, with the Pacific. Besides these it was proposed to build a loop line around the south shore of Lake Baikal, connecting the two first-named lines.

The river Obi is, by means of its tributaries, the Irtish and the Tobol, and by the Toura, a tributary of the Tobol, connected with the Oural Railroad, the eastern terminus of which is at Tumen on the Toura, while its western terminus is at the city of Perm, which is on the Kama, a tributary of the Volga; but as Perm has at present no railroad connections with the Russian railroad system, these proposed Siberian lines would be connected by steam with European Russia only during summer and the season of open navigation, which on the Kama lasts about five months, on the Obi about four and one-half months, and on the Amour about six months.

Accordingly, in addition to this connection, the new Minister of Roads and Communications, M. A. Hubenett, proposed to connect the Oural Railroad at Ekaterinbourg with Chelabinsk, a point which will be this year reached by the Samara-Oufa-Zlatooust Railroad. This road will have a through connection with the other Russian railroads, and was called by the former minister, M. C. Possiet, the first link of the Siberian Railroad.

Notwithstanding the decision of the Commission of Ministers—a decision which, if carried out, would keep the Central Siberian Road practically separated from European Russia during the seven or eight months of the winter—one of the most eminent of Russian engineers, N. P. Mejeninov, who was Chief Engineer in charge of the surveys of the Central Siberian Railroad, presented a memorial to the Government expressing the opinion that the Siberian line should be constructed as an extension of the Samara-Oufa Railroad, and that only in this way would it form a through line connecting the European railroad system with the Amour settlements, and thus satisfy the political and commercial needs of the country.

This opinion is further confirmed by the unsatisfactory condition of navigation on the water-way from Tumen to Tomsk, which is 1,870 miles in length, and is formed of the rivers Toura, Tobol, Irtish and Obi. The three former rivers are very tortuous in their course and changeable in channel; the Obi is easily navigable except in one place, at Laminsor, while from Tobolsk to Tomsk there is no postal or telegraphic connection, and the banks of the river are entirely uninhabited. In this water-line navigation is usually open from the end of May to the end of September, about 135 days; the passenger steamers usually make six round trips and the freight steamers only three. There is only one steamship company, and the greatest load which can be transported in one season is 60,000 tons. The charge for the trip is from 15 to 25 copecks per poud, which is about $4.80 to $7.20 per ton, for a distance of 1,870 miles.

By consulting the map of Siberia, it will be seen that the memorial of M. Mejeninov proposes the building of an additional line from Zlatooust to Tomsk, or rather the extension to the former point of the Central Siberian Railroad, which, according to him, should begin, not at Tomsk, but at Zlatooust. The additional line, about 1,000 miles, traverses a very fertile and level country, crosses no great rivers, and could be built at a low rate. Its total cost would probably not exceed 50 000,000 to 60,000,000 roubles.

As it is almost certain that this opinion will prevail, and as the Samara-Oufa Railroad in any case will be part of the Siberian system, I have considered it best to describe the line already completed and the extensions toward Zlatooust now under construction, and to Chelabinsk, the building of which has been decided upon, before beginning an account of the surveys of the Siberian Railroad proper.

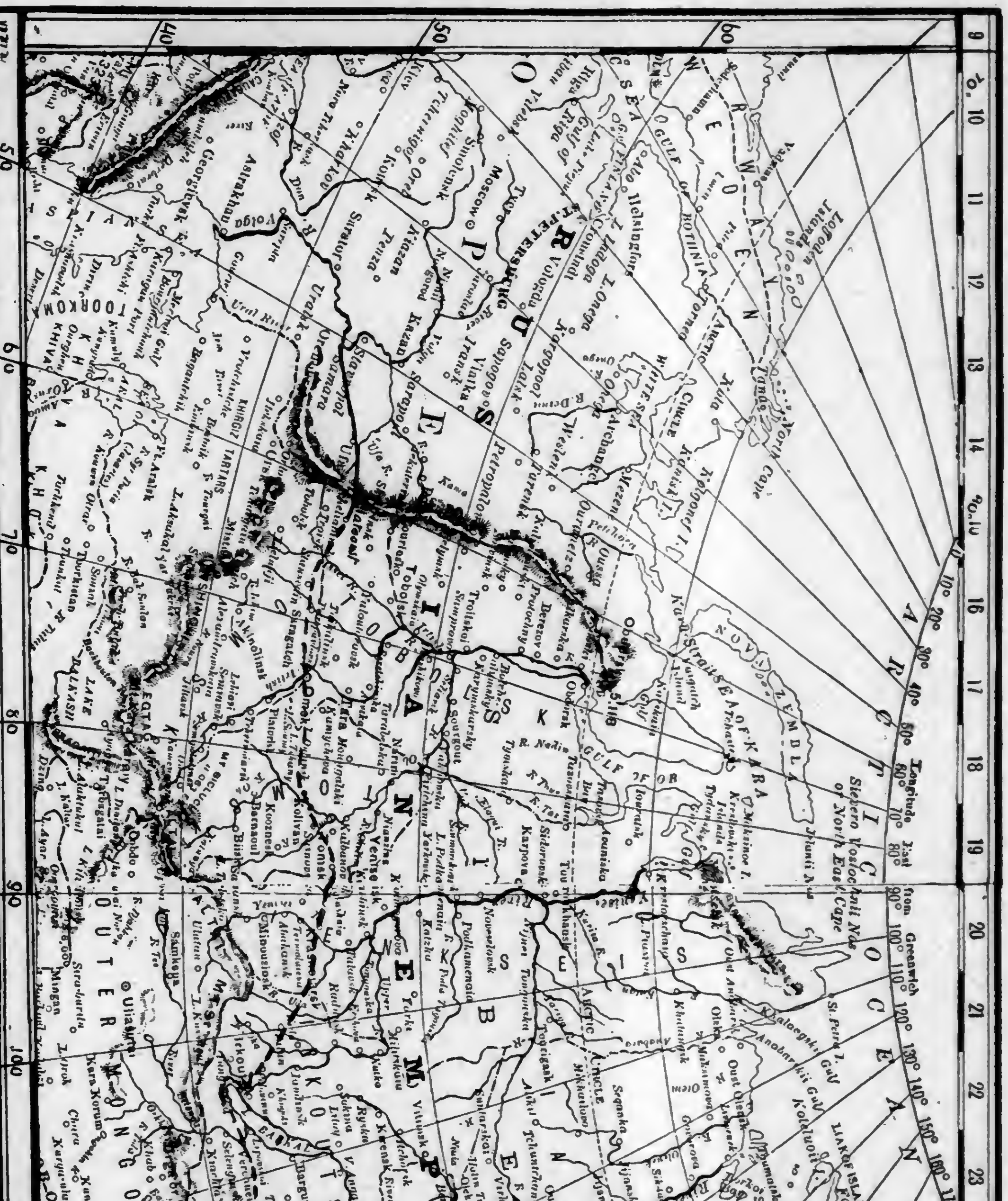
THE SAMARA-OUFA RAILROAD.

It is not without reason, as stated above, that this road has been called the first link of the great Siberian line. Samara is the only town on the eastern shore of the Volga River which is connected by an iron bridge—the longest in Europe—with the eastern bank of that river. All the other towns—Nijni-Novgorod, Saratov, Tsaritsin—which are terminal railroad points on the Volga have no bridges, and the lines reaching them do not cross the river. Under these conditions Samara was pointed out as the proper starting-point, and the town through which must pass the great traffic between Europe and Asia.

The building of this road was decided upon by the Government in 1885. It was built directly by the Government, under the superintendence of the State Railroad Direction. In the summer of 1885 the final survey and location were made; in the following winter the necessary preparations were completed, and in May, 1886, work was begun on the whole line. It was completed in August, 1888, and formally opened September 8–20 The total length of this road is 453 versts (302 miles); it begins at Kinel on the Orenbourg Railroad, 38 versts (25 miles) from Samara, the section from Kinel to Samara being used by both roads. From the starting-point the line follows up the valleys of the Kinel and Kista rivers, then rise over the divide between the water-sheds of the Volga and the Kama, reaching a level 980 ft. above Oufa; then descends by the valleys of the Koursak and Dioma rivers to the Bielaia or White River, and crosses this river on a large iron bridge, reaching the terminus at Oufa, on the right bank of the White River, near the Sofronov Landing, the point at which the navigation of the White River begins.

The greatest distance between stations is 16 miles, and the passing places on the single-track line are so arranged as to permit the running of nine trains daily in each direction; but the present supply of rolling stock is sufficient only for one mixed train and two freight trains daily in each direction. The grade and bridges are built for single-track only, and the standard width of grade is 18 ft.

The construction of this road presented many difficulties. It was impossible to find workmen enough along the line, and the contractors had to bring some 20,000 laborers from Central and Eastern Russia. The summer working season is very short, lasting only about five months, and therefore as much work as possible was performed in the winter. For materials, only limestone was found near the



SIBERIA AND THE GREAT SIBERIAN RAILROAD.

NOTE.—The heavy black line from Samara to Chelabinsk shows the section completed or under construction; the dotted line from Chelabinsk eastward shows the proposed line of the road as described.

line. There was no timber, and all that was used had to be carried either from Samara, Oufa or Sterlitamak, a distance of 140 miles, so that the supply of ties was very difficult to obtain. There was little or no material for ballast, so that the gravel used had to be hauled an average distance of two miles to the line of the road, and 12 miles along the line. All the machinery and supplies for the equipment of the line, water stations, tools for workshops, etc., were made in Russia and from Russian raw materials. The sheet-iron used for roofing buildings and most of the rails were supplied from the Oural Iron Works, and the iron for the bridges from the Government Works at Votkinsk. Cement was obtained from the works of Schmidt & Company in Riga, Port-Kund in Revel, and the Moscow Company in Podolsk. The materials were carried to the terminal points of the line by water in summer, and during the winter were hauled out on the line by teams, with the exception of the rails and ties which were carried by the work trains. All the work was sub-let to contractors on the basis of price per unit of work. The work done directly by the Government amounted to only 584 000 roubles. The cost of this line, 302 miles in length, was as follows :

Part of Work.	Cost in Roubles.		Per Cent. of Total.
	Total.	Per Mile.	
Grading and substructure	17,082,932	56,566	71.7
Rails and fastenings	3,663,628	12,131	15.4
Rolling stock	3,075,178	10,183	12.9
Total	23,821,738	78,880	100.0

The cost here is given in roubles, and they are not converted into dollars for two reasons : the exchange price of the rouble, nominally about 50 cents, is very variable, and the comparative cheapness of labor in Russia is such that for a rouble almost as much work can be obtained as for a dollar in America by a contractor.

The highest grade on the road going eastward is 1 per cent., and going westward 0.8 per cent. The minimum radius of curvature is 1,400 ft. The earthwork on the line was not easy, the average quantity moved being 53,640 cubic yards per mile ; but there were miles where the quantity rose to 950,000 cubic yards per mile. The greater part of the earthwork, about four-fifths, was embankments, the line being placed at a high level in order to prevent snow blockades. The smallest embankments are from 2½ to 3½ ft. in height. The highest embankment is 70 ft., and is a dam or bank 3,640 ft. long in the valley of the White River.

From Kinel to Oufa the line crosses the following rivers : the Koutouluk and the Kourtamak, tributaries of the Kinel ; the Little Kinel ; the Kinel, a tributary of the Samara ; the Ik, a tributary of the Kama ; the Kaursak, a tributary of the Dioma ; the Tulen, the Oudriak, the Balashly, the Kalmash, the Ouza, and the White River. The last-named bridge has six spans, each of 350 ft. clear opening.

There are only two kinds of bridges used, masonry arch culverts and iron bridges. The arch culverts are 80 in number, and vary in span from 3½ to 17½ ft. All the other bridges have masonry abutments and iron superstructure, and their number and size are given in the following table :

No. of Bridges.	Clear Span of Bridge in Feet.	Weight of Superstructure of One Bridge.	
		Deck Bridge.	Through Bridge.
110	7	1,908 lbs.	....
97	14 to 56	....	....
2	70	48,000 lbs.	76,900 lbs.
1	105	....	137,600 lbs.
3	140	203,800 lbs.	242,100 lbs.
3	175	332,500 lbs.	334,000 lbs.
2	210	499,300 lbs.	489,200 lbs.
1	350 (6 spans) White River Bridge	....	1,262,600 lbs. (1 span).

The total weight of iron used in the bridge structures was 5,847 tons. The arch culverts are of brick or stone, and the abutments of the iron bridges of limestone. As good stone was scarce, at many points it had to be carried 80 miles from the quarries to the point where it was needed. The sandstone for the ice breakers of the piers of the White River bridge was floated 200 miles down the river. The abutments of the small bridges up to 14 ft. span have a common foundation, and the masonry is all of good class.

The most conspicuous structure on the line is the White River bridge. The piers and abutments are founded on caissons sunk by pneumatic process. The foundation for the piers is 56 ft. below the low-water level, and the foundations of the abutments are respectively 42 and 49 ft. below low-water level. The masonry is of limestone, which was brought 100 miles down the Oufa River. This stone has an ultimate resistance of 8,750 tons per square inch to crushing. The up-stream faces of the piers and the ice-breakers were of sandstone brought 200 miles down the river from the Oural Mountains. This sandstone has double the strength of the limestone, its ultimate resistance being 17,500 lbs. per square inch. The superstructure of this bridge was designed by Professor N. A. Beleloubski, and is a through truss of semi-parabolic system with double intersections, somewhat resembling the Linville truss. The chords are of channel shape. The posts are made of four or more separate angle-bars placed at such a distance apart that the floor-beams could be fixed between them. The chief feature of this bridge is that the floor-beams are not riveted to the lower chord, but are carried on special hinges or links, so that the strain from the floor-beams is transmitted to the center of the chord, avoiding all torsional strains of the channel-bars, and therefore the strain on the lower chord is much less. This system of hanging the floor-beams requires separate cross-girders to connect the lower chords.

The ballast used on the road is sand and gravel, principally sand. It is laid 15 in. thick under the rail, and the general width of the ballasted road-bed is 10½ ft.

The ties are of pine and spruce, and are generally of semicircular section, split from logs 10½ in. in diameter. There are also some ties 8½ × 6 in. in section. Their length is everywhere 8 ft., and they are spaced 2½ ft. apart, so that 2,160 ties to the mile were used.

The rails are of steel and are of two types, the first 67½ Russian pounds (61½ English pounds) to the yard, and the second 72 Russian pounds (66 English pounds) to the yard. The rails are 24 ft. long, and each has a bearing upon 10 ties. The joints are angle splices with two underplates fixed by means of bolts and spikes, and are placed between the ties. The rails are, as usual in Europe, inclined slightly toward the axis of the track. The gauge of the road is the standard Russian gauge of 5 ft.

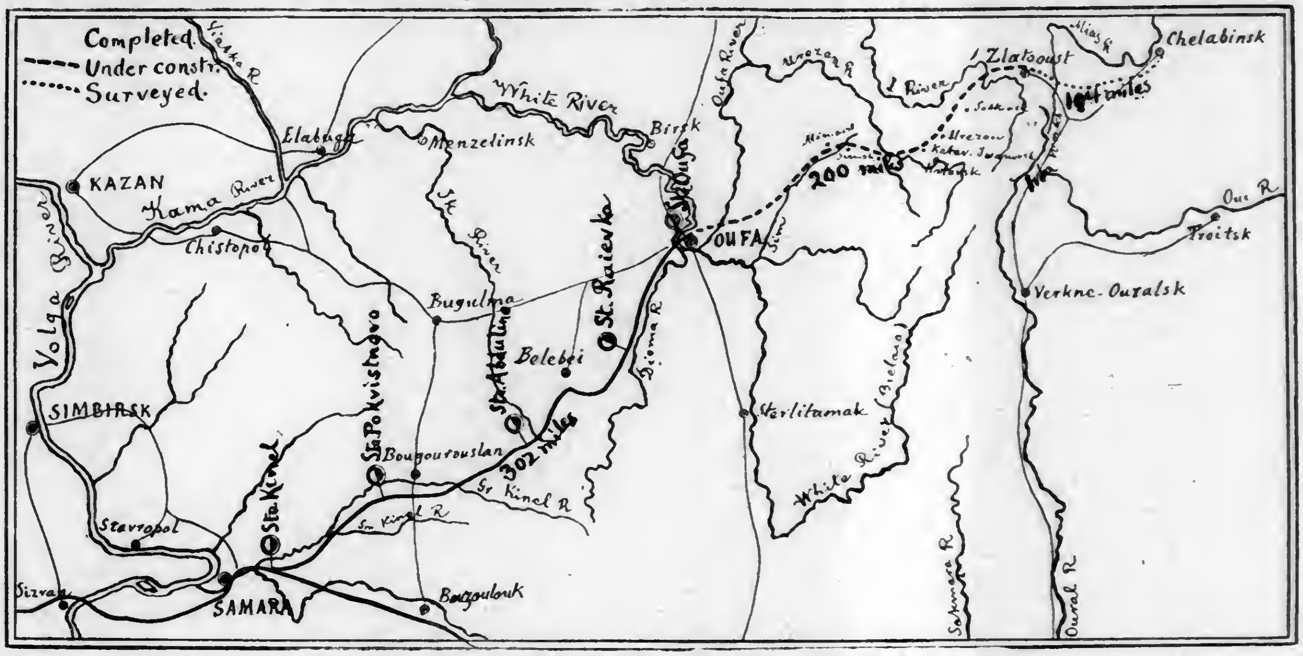
The buildings would be considered numerous and luxurious on an ordinary American road. Under the system of protecting the track, at every two miles and near each crossing there is a watchman employed ; on each section is a roadmaster with a suitable gang of trackmen. For the accommodation of these men there are 233 watchmen's houses and 47 section-houses, 25 of the latter being at stations and the remaining 22 at points between stations. All of these buildings are of wood placed on masonry foundations. There are 267 road crossings, and almost every one is protected by a gate and watchman.

The station buildings are of the standard Government railroad type and are 25 in number, two of them being of the second class, three of the third class, and 20 of the fourth class. No first-class buildings were put up, as, according to the regulations, such buildings must be provided with luxurious and costly apartments for the use of the Emperor. Of these stations and buildings, 23 are of brick and two of stone. There are only four separate freight stations, but others will be built as their necessity is shown by the operation of the road.

The engine-houses are of brick or stone, with wooden roofs covered with paper. They have wooden floors and are heated with round stoves. There are five of these engine-houses, all of rectangular form, and having altogether 43 stalls.

The repair shops of the road are at Oufa, and consist of three buildings : the first covers an erecting and paint

shop, 133 × 126 ft.; a machine shop, 161 × 56 ft.; a wheel and spring shop, 59 × 56 ft.; a smith shop, 72 × 56 ft.; a brass foundry, 28 × 56 ft.; an engine-room, 31½



MAP OF THE SAMARA-OUFA-ZLATOOUST RAILROAD.

× 21 ft., and a boiler-room, 42 × 35 ft. The second building covers two car-repair shops each 119 × 45½ ft. and a paint shop 70 × 119 ft., while the third and smallest building includes a wood-working shop 52½ × 70 ft. There is also a small separate smith shop for car work, 24½ × 16 ft. in size. All the buildings are of masonry with sheet-iron roofs, but the smith shop and foundry are roofed with corrugated galvanized iron. The roof trusses in the largest building are of iron; in the other departments they are of wood. Besides these shops there are three small shops at other points on the line, for making ordinary running repairs.

According to the Russian system of operating the railroads, the Government provides lodgings for all the officers and employés. This has required the building of 86 houses of various sizes, all of wood on masonry foundations, and placed at various stations along the line. The country is very thinly inhabited, and more houses are now found to be necessary.

A water supply is necessary at each of the 23 stations, and the arrangements are uniform in character. At each of these there are iron tanks protected by wooden covering, and placed on masonry piers. The tanks are generally of 2,744 cubic feet capacity, with the bottom elevated about 28 ft. above the level of the rails. They are placed usually about 100 ft. from the main track, and for filling the tenders hydraulic cranes are placed close to the track. At one station the tank is supplied from a high level by means of gravity, but at the other 22 pumping engines are required, which vary from 4 to 10 H. P.

The stations are fully equipped with signals and switches, and for this purpose there were used 259 ordinary switches, 2 triple switches, 49 iron semaphores, 49 green signal disks at stations, 110 stop-blocks, and 60 switch-houses. There are five turn-tables of the Sellers pattern, 55 ft. in diameter. The station yards are paved, and are provided with gardens and fences.

The rolling stock is of the European type and without trucks. There are on the road 31 six-wheeled engines weighing 32 tons each without fuel or water; 29 eight-wheeled freight engines weighing 42 tons each. The passenger rolling stock consists of one officer's car; six cars with first and second-class compartments; eight second-class cars; 12 third-class cars; five combination third-class and postal cars, and four special cars for the transportation of exiles. The freight equipment consists of 640 box-cars and 160 open or flat cars. The capacity of a Russian freight car is usually 21,000 lbs., and the weight of a box-car about 14,000 lbs.

As to the cost of the road, it will not be without interest to give a detailed statement of the distribution of the cost of the works on this road, which, as before stated, is 302 miles in length, and such a statement is given in the following table:

	Description of Work.	Cost in Roubles. Total.	Per Mile.	Per Cent. of Total.
1	Expropriation, lands, etc	316,262	1,047	1.3
2	Earthwork	4,355,464	14,422	18.2
3	Bridges	5,010,894	16,592	21.0
4	Track	5,585,379	18,495	23.4
5	Road accessories	84,991	281	0.4
6	Telegraph line	118,151	391	0.5
7	Road buildings and gates	493 337	1,632	2.1
8	Station buildings	1,591,079	5,268	6.7
9	Water supply	443,689	1,469	1.9
10	Station accessories	475,688	1,575	2.0
11	Rolling stock	3,519,928	11,655	14.8
12	Road and landing in Oufa	54,867	182	0.2
13	General expenses	1,349,692	4,469	5.7
14	Extraordinary expenses	104,769	347	0.4
15	Comptrolling and police	111,234	368	0.5
16	Sundries	192,855	639	0.8
17	Loss on material and property	13,459	45	0.1
	Total	23,821,738	78,877	100.0

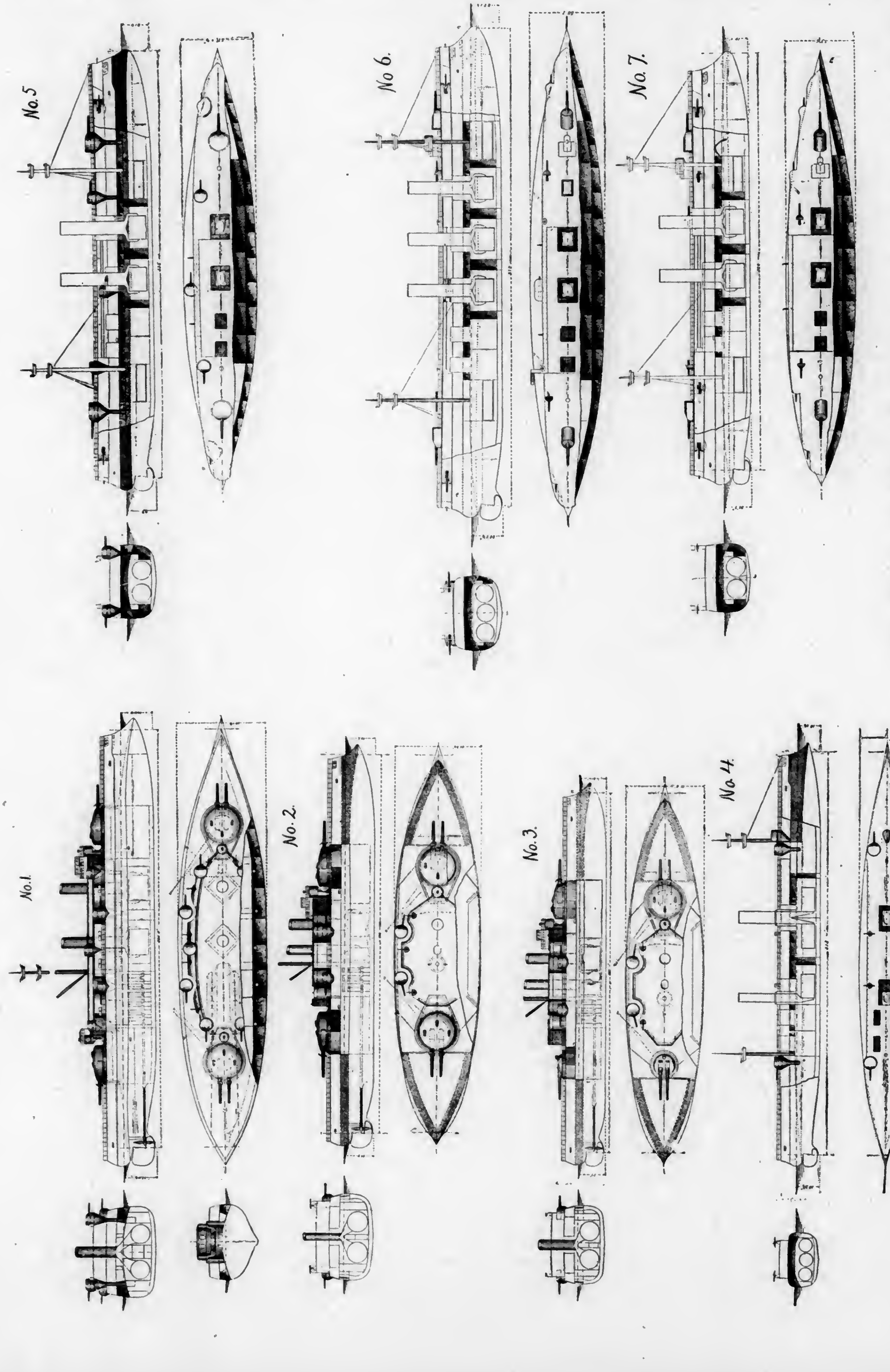
Of the sum expended for bridges, the cost of the White River bridge formed 46 per cent., the amount being 2,306,075 roubles.

The actual cost of the rolling stock was 3,075,178 roubles, but to this was added 444,750 for transportation and other charges, bringing up the total to 3,519,928 roubles, as given above.

The item of track was made up as follows: Rails, 3,181,009; fastenings, 482,618; ties, ballast and track-laying, 1,192,752; total, 5,585,379 roubles, as above.

UNITED STATES NAVAL PROGRESS.

The Report of the Naval Policy Board, to which reference has heretofore been made in our columns, not only outlined a plan for the future increase of the Navy, giving the numbers of each class of ships which would be required to make a naval force appropriate to the position and power of the United States, but presented plans for a number of different classes of ships which should be used. The accompanying sketches present these plans reduced to a small scale, which is sufficient, however, to show their general features, as in such a report as that pre-



DESIGNS FOR WAR-SHIPS SUBMITTED BY THE NAVAL POLICY BOARD.

sented by the Board it was, of course, not necessary or practicable to carry these plans out to minute details. We give below also a description of each class, which is necessarily very brief. The number attached to each sketch corresponds to the number in the text below.

No. 1 is the type plan of the Board for a first-class battle-ship of great coal endurance. The leading dimensions of this plan are: Length over all, 349 ft. 2 in.; length on load water-line, 340 ft. 2 in.; length between perpendiculars, 326 ft. 6 in.; extreme beam, 71 ft. 6 in.; beam on load water-line, 69 ft. 9¾ in.; mean draft, 25 ft. 4½ in.; diplacement, 10,000 tons. Generally speaking, it may be said that this ship is to have a double bottom, engines and boilers in separate water-tight compartments, and the ship, generally, divided into many compartments. There would be a wide belt of 5-in. armor extending the whole length of the vessel about 5 ft. below and 5 ft. above the water-line; an armored deck 3 in. in thickness; the redoubt shown on the plan to have 16-in. armor; the turrets also 16-in. armor, and the barbettes for the guns 3-in. armor. There would be two turrets each carrying two heavy guns. The armament would consist of four 12-in. guns, ten 5-in. guns, 20 small rapid-fire guns, and six torpedo tubes. Four engines would be provided, two on each shaft, and they would be expected to develop 11,000 H.P. with forced draft, and to bring the ship up to a maximum speed of 17 knots. The provision for coal would permit of carrying a total of 1,350 tons, or of 675 tons at load draft.

No. 2 shows the design for a first-class battle-ship of limited coal endurance. The principal dimensions are: Length over all, 314 ft.; length on load water-line, 306 ft.; length between perpendiculars, 296 ft.; extreme beam, 67 ft. 9½ in.; mean draft, 23 ft. 3 in.; displacement, 8,000 tons. The armor provided for in this design is a belt of 17 in. in thickness, 164 ft. in length, and about 8 ft. in width at the water-line, ending in bulkheads of 14 in. in thickness; an armored deck above this belt and a submerged deck 3 in. thick extending to the ends of the vessel. The redoubts and turrets would have a thickness of 17 in. of armor and the casemate 4 and 5 in., with appropriate protection for the smaller guns. The armament would consist of four 13-in. guns, four 5-in. guns, 12 smaller rapid-fire guns, and six torpedo tubes. Two triple-expansion engines would furnish the power and would be expected to indicate 7,500 H.P. with forced draft, and to drive a vessel at a maximum speed of 15.8 knots. The total coal capacity is given at 500 tons and the normal supply at load draft 300 tons.

The second-class battle-ship would be similar to this in all respects, but would be somewhat shorter, 290 ft. between perpendiculars, and have a displacement of only 7,100 tons and a somewhat lighter battery.

No. 3 shows the third-class battle-ship of limited coal endurance, which is of very similar plan, but the following dimensions: Length between perpendiculars, 280 ft.; extreme beam, 65 ft. 6 in.; mean draft, 21 ft. 6 in.; displacement, 6,000 tons; to have two triple-expansion engines capable of working up to 6,500 H.P. and of giving a speed of 15.8 knots. The armor would be somewhat lighter than that in the first-class ship, including a water-line belt 15 in. thick, 155 ft. long, with bulkheads 13 in. thick; an armored deck 2½ and 2¾ in. thick; redoubts with 15-in. armor; a barbette with 12½ in. and a casemate with 4 in. of armor. The battery would include two 12-in. guns, two 10-in. guns, four 5-in. guns, 16 small rapid-fire guns, and six torpedo tubes.

No. 4 shows a ram for harbor defense carrying only a limited supply of coal, as it is not expected to be used as a cruiser. The general dimensions of this are: Length between perpendiculars, 313 ft.; extreme beam, 42 ft. 1½ in.; mean draft, 18 ft. 2½ in.; displacement, 3,500 tons. On this vessel, for a length of 70 ft. forward, protection would be afforded by side armor of 4 in. worked on heavy Z-frames extending from the armored deck to below the water-line; abaft this bulkhead the protection to be continued by an armored deck with double side slopes. The engines would be of the triple-expansion type, four in number, two on each shaft, capable of working up to 9,700 H.P., and of giving a maximum speed of 20½ knots with forced draft. The armament would consist of four 5-in. guns, 11 small rapid-fire guns, and two torpedo tubes.

No. 5 gives the type plan for a first-class thin armored cruiser, which would have a length between perpendiculars of 335 ft., an extreme beam of 67 ft. 6½ in., a mean draft of 22 ft. 3 in., and a displacement of 6,250 tons. This vessel would be protected by a complete belt of armor 8 ft. wide, varying from 5 to 4 in. in thickness, extending the whole length of the vessel, and by an arched armored deck from 2¼ to 2¾ in. thick. There would also be a belt of water-excluding material. The plan provides for four triple-expansion engines, two on each shaft, capable of working up to 9,800 H.P., and giving a maximum speed of 19 knots. The coal supply at load draft would be 625 tons, and on this supply the steaming distance at full speed would be 2,100 miles, or at low speed 7,000 miles. The battery would consist of two 8-in. guns, ten 5-in. rapid-fire guns, 18 small rapid-fire guns, and six torpedo tubes.

No. 6 shows the plan for a first-class protected cruiser having a length between perpendiculars of 372 ft.; a beam of 58 ft. 7 in.; a mean draft of 23 ft. 1½ in., and a displacement of 7,500 tons. This ship would be protected by an armored deck, a belt of water-excluding material, and the arrangement of the coal bunkers to protect the machinery. It would have four triple-expansion engines, which could be worked up to 20,250 H.P., giving the ship a maximum speed of 22 knots, great speed when necessary being considered essential to this class of vessels. A coal supply of 900 tons at load draft is provided for, and 1,600 tons in all could be carried, the latter supply giving a cruising range at low speed of 15,000 miles. The armament would be substantially the same as that of the thin-armored cruiser, consisting of two 8-in. guns, ten 5-in. rapid-fire guns, 18 small rapid-fire guns, and six torpedo tubes.

No. 7 is a plan for a second-class protected cruiser having a length between perpendiculars of 324 ft.; an extreme draft of 53 ft. 6 in.; a mean draft of 20 ft. 7 in., and a displacement of 5,400 tons. This ship also is protected in the same way as the first class cruiser—that is, by an armored deck, a belt of water-excluding material, and the arrangement of the coal bunkers. It would also have four triple-expansion engines, giving 12,000 H.P. with forced draft, and a speed of 20 knots, with a total cruising range at low speed of 11,200 miles. The armament would consist of two 8-in. guns, twelve 5 in. rapid-fire guns, 14 small rapid-fire guns, and six torpedo tubes.

The report also recommends several other classes of vessels, smaller cruisers, gun-boats for special service, torpedo boats, and ships for torpedo depots and for repairs, for which no plans are given.

It is believed that the brief descriptions given above, with the plans, will be sufficient to give a general idea of the vessels recommended by the Board, and we also add below a summary of the general recommendations presented in its report as to the principles which should govern the plans for new vessels.

1. *Hulls* to be of mild steel, all riveting to be by machine, and the limit of tensile strength to be 10 to 20 per cent. greater than now used. As little wood-work as possible to be used.

2. *Armor* to be of steel, on thin backing against heavy plating; protective decks to be carried on heavy beams. Extensive use to be made of woodite as a subsidiary protection; this material to be used for water-line belts and similar purposes. All guns to be protected by shields when not enclosed in barbettes or turrets.

3. *Guns* to be arranged so as to obtain a large proportion of the total fire on all bearings. The heaviest proposed is 13 in., 35 calibers long, weighing about 60 tons; the next 12 in., 35 calibers long, weighing 50 tons. Other types include the 8-in. and 5-in. breech-loading rifles, 5-in. rapid-fire, and two sizes of small rapid-fire guns—6-lbs. and 1 lb.

4. *Engines* to be of the triple-expansion type, using steam of 160 lbs. pressure; for nearly all the ships four engines to be used, two on each shaft. This involves somewhat more space and weight, but better proportioned engines can be obtained, and for cruising at low speeds

only two engines need be used. The boilers proposed are of the cylindrical type; forced draft to be by the closed stoke-hole method.

PROPOSALS FOR A PROTECTED CRUSIER.

Proposals will be received at the Navy Department until June 10 for the new protected cruiser. This ship is to be built on the double-bottom cellular system, with numerous water-tight compartments, and will have an armored deck 4¾ in. thick on the slopes and 2 in. thick on the flat over the machinery spaces; 3 in. on the slopes and 2 in. on the flat, fore and aft. A belt of woodite 33 in. thick, in coffer-dams extending 4 ft. above and 4 ft. 5 in. below the load water-line, extends the whole length of the vessel. Coal protection is afforded to the machinery by the location of the bunkers along the side below the protective deck and above the deck for the length of the boiler and engine space. The hull plating is increased in thickness in wake of all machine guns.

The general dimensions are: Length on load water-line, 314 ft.; extreme breadth, 53 ft.; mean draft, 21 ft. 6 in.; displacement, 5,500 tons.

There are to be two screws, each driven by a triple-expansion engine with cylinders 42 in., 59 in., and 92 in. in diameter and 42 in. stroke. There will be six boilers, built to carry 160 lbs. working pressure. These engines are to work up to 13,500 H.P. with forced draft, and to give the ship a maximum speed of 20¼ knots. The total coal supply will be 1,300 tons, which will give a cruising range of 2,200 knots at full speed or 13,000 knots at half speed.

Minor points include steering-gear entirely below the protective deck; a full electric-light system; artificial ventilation by blowers; two steel masts with double fighting tops. The quarters will have provision for 25 officers and 441 men.

The main battery is to consist of two 8-in. and ten 4-in. breech-loading rifled guns. The 8-in. rifles are mounted on the center line in barbette turrets 4 in. thick, one at the forward and one at the after end of the superstructure, and train from directly ahead or astern to 50° on each side, abaft or before the beam, respectively. The ammunition is supplied through armored tubes 3 in. thick, which permit loading in any position. The 4-in. guns are mounted on improved central-pivot mounts, and protected by fixed segmental shields 4 in. thick; four of these guns forward have a fire from direct ahead to 63° abaft the beam; the four after guns have a similar train before the beam; the two 4-in. guns amidships have a broadside train through 146°. The fire of all the forward and after guns respectively can be concentrated upon an object the length of the vessel directly ahead or astern. The secondary battery will consist of eight 6-pdr. and six 3-pdr. rapid-fire guns, and 14 machine guns, mounted to be clear of the smoke and fire of the main battery and for efficient action against boat attacks. Wherever practicable protection is afforded the machine guns by plating 2¼ in. thick. In each of the lower military tops are mounted a 37-mm. Maxim and a 1-pdr. Hotchkiss gun. An allowance of 150 rounds will be provided for each of the 8-in. and 4-in. guns. An average of about 3,600 rounds is allowed for each of the guns in the secondary battery.

The torpedo outfit consists of six launching tubes for Howell automobile torpedoes, one fixed at the stem, one at the stern, and two training tubes on each broadside.

TRIAL TRIPS OF NEW VESSELS.

The preliminary trial of the *Philadelphia* was made by a trip down the Delaware and a short distance out to sea; the results are not reported, as the trial was not an official one, but it is stated that they were very satisfactory to the builders, and that the speed of the ship and her general action under steam were fully equal to expectations.

The torpedo-boat *Cushing* has been sent from the builders' yard at Newport to the Washington Navy Yard. The official trials will take place shortly, and the results are looked for with interest. The *Cushing* showed very good speed on her trip to Washington, although no attempt was made to drive her to full power.

THE DEVELOPMENT OF ARMOR.

BY FIRST LIEUTENANT JOSEPH M. CALIFF, THIRD U. S. ARTILLERY.

(*Continued from page* 217.)

XII.—THE CONFEDERATE IRON-CLADS.

FROM the beginning, the Confederate naval authorities were far more alive to the necessity of armor-clad vessels than our own. Their construction, however, was attended with difficulties of which we knew nothing. Except the Tredegar Works, at Richmond, there were, at the beginning, no mills capable of rolling armor-plate; there were few or no merchant steamers beyond a river steamboat that could be converted for naval use, and few facilities for building new ones; iron was scarce, and trained seamen hard to get. Later on rolling mills were established at Selma and Atlanta. Notwithstanding these disadvantages, the armored fleet turned out was an exceedingly creditable and serviceable one.

The *Merrimac* or *Virginia*, as they called her, was the first essay in the direction of an iron-clad. As already stated, this vessel was well under way before the keel of the *Monitor* was laid down. The hull of the old frigate *Merrimac* served as a foundation, and upon this a casemate 140 ft. in length was erected, with sides sloping at an angle of 35°. The armor was rolled out of railroad iron into plates 8 in. in width and 2 in. in thickness. Two layers of these iron slabs were secured to the sides and ends of the casemate; the inner layer horizontal, the outer

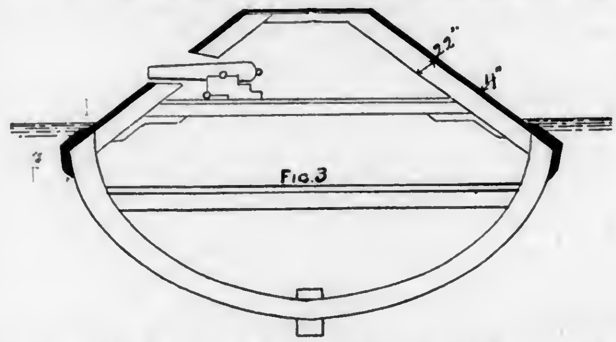


FIG. 3

one vertical. The wood backing was 22 in. in thickness, through which the armor bolts were driven and clinched on the inside. The pilot-house at the forward end of the casemate was conical and armored. Iron gratings covered the top of the casemate. Fig. 3 gives a cross-section, and shows the method of applying the armor. The sides of the casemates were carried 2 ft. below the water-line, and the ends were submerged the same distance. The armor was continued down to the knuckle, where it was clamped. Bulwarks were erected around the submerged ends. The *Merrimac* served, in all essential particulars, as a model upon which all of their subsequent iron-clads were built.

Built for the defense of Mobile, the *Tennessee* may be said to have been the most powerful, if not the most creditable production of the Confederate naval authorities. With the exception of her engines, she was built entirely of home-prepared material. She was a casemated iron-clad much like the *Merrimac* in general design, with a casemate some 80 ft. in length, whose sides and ends sloped at an angle of 45°. Like the *Merrimac*, the casemate was carried 2 ft. below water, and then returned to meet the sides some 7 ft. from the water-line. The knuckle projected 10 ft. beyond the casemate, and afforded ample protection against an enemy's rams. The armor on the sides was 6 in. in thickness, made up of three 2-in. plates 7 in. in width. On the ends the armor was 5 in. in thickness, all secured by through bolts set up with nuts on the inside. Behind the armor was a backing of 25 in. of oak and yellow-pine. Two inches of iron protected the deck, and the ports were closed with 5-in. sliding iron shutters.

The iron-clad ram *Atlanta* is said to have been built with a special view to raising the blockade along the South Atlantic Coast. When finished her constructors evidently believed her to be more than a match for any of the blockading fleet. It was a case of sadly misplaced confidence. The hull of a blockade-runner supplied the foundation upon which a casemate with inclined sides and ends was erected. Upon the 18 in. of pine and oak backing two layers of 2-in. armor-plate, rolled out of railroad iron, were fastened. To obtain the necessary flotation a raft of timber was built over the deck and 6 ft. out from the sides, where it met the slope of the casemate. The armor was secured by through bolts and nuts. A ram and torpedo-spar completed her equipment.

Perhaps no war vessel was ever constructed under greater difficulties than the *Albemarle*. Built in an open cornfield, of unseasoned timber, and with only such aid as was afforded by a common country blacksmith's forge, of which not only the material for the iron plating but much of that for the machinery was literally picked up in bits, wherever it could be found, it was a brilliant illustration of what well-directed and untiring energy can do.

The foundation had much the appearance of an immense flat-bottomed scow. Upon this was a 60-ft. octagonal casemate with sloping sides and plated with two layers of 2-in. iron. Like all the Confederate iron-clads, the *Albemarle* had no engines that could properly propel her. Had she been otherwise provided in this respect, it is quite probable that she would, temporarily at least, have cleared the sounds of North Carolina.

At Charleston four iron-clad rams were built, but beyond a single raid, in which one wooden gun-boat was completely disabled and another compelled to surrender, nothing was accomplished. All were captured or blown up at the capture of the city.

Of the three iron-clads that formed the James River fleet only one needs mention—the *Virginia* (not of *Monitor* fame)—from the fact that she was provided with heavier armor than any other Confederate iron-clad, 6 in. side and 8 in. end armor on her casemates. None of them took a prominent part in hostilities, but the moral effect of their presence as a factor in the defense of Richmond was not inconsiderable. They were destroyed upon the evacuation of the city.

For the defense of New Orleans and the lower Mississippi, the iron-clads *Louisiana* and *Mississippi* were designed. The latter was never completed, and the former was barely so when Farragut forced the defenses of the city. Her engines were so inadequate that her only part in the defense was that of a floating battery. Her casemate was armored with railroad iron, of which several hundred tons were used. She was set on fire and blown up by her commander.

On the Yazoo River the Confederates completed the *Arkansas*. Unlike their other casemated iron-clads, the ends of the casemate only were inclined. Iron taken from railroad tracks supplied the armor. The rails were placed horizontally along the sides and up and down on the ends, and dovetailed together. With a substantial wood backing this improvised armor gave a remarkably good account of itself during subsequent operations.

The weak point in every one of the Confederate iron-clads lay in their machinery. None of them had engines that could propel them more than six knots an hour under the most favorable conditions, while many of them could hardly be given steerage way. What the *Albemarle*, the *Arkansas* or the *Tennessee* could have done if provided with powerful machinery can well be imagined. Generally speaking, their armament consisted of 6 and 7-in. converted rifles.

XIII.—THE TEST OF BATTLE.

In February, 1862, the first armor-clad vessels built in the United States received their baptism of fire. When the advance against Forts Henry and Donelson had been decided upon by General Grant, four of the eight iron-clads built by Captain Eads were ordered to co-operate, under Flag-Officer Foote. These boats were under control of the War Department, and a detail from the Army had been promised to help man them. Only a small detachment reported, and so difficult was it to obtain men that four of the iron-clads were left behind for want of proper crews.

In the attack on Fort Henry, the Confederates brought 11 guns to bear—a 60-lb. rifle, a 10-in. columbiad, and the remainder 32 and 42-lb. smooth-bores. It will be remembered that these vessels were armored only on the front ends of their casemate and abreast the machinery on the sides. The action opened at 1,700 yards, and the distance was gradually reduced to 600, and was continued a little more than an hour. The flag-ship was struck 32 times and one of her consorts 30 times. Although the armor was in many places badly shattered, the general result of this, the first test, was to demonstrate the ability of even $2\frac{1}{2}$ in. of inclined iron armor to keep out any projectiles likely to be encountered on the Western rivers. The great defect in these vessels, as shown by this action, was the leaving of so large a portion of the sides unprotected, and the neglect to provide armored shutters for the gun-ports. Smoke-stacks were badly damaged, and we read of after-cabins being riddled with shot and of guns disabled by shot coming through the ports or unarmored sides. The most serious mishap was that of a shot coming in over one of the bow-guns of the *Essex* and entering one of the boilers. Twenty-eight of the 39 casualties which occurred in the fleet were from escaping steam in this instance.

At the end of the hour the batteries on shore were in a sorry plight. The 60-pounder rifle had burst; the columbiad became accidentally spiked, and five of the remaining guns had become disabled. A storm had delayed the troops, so that the action was fought and won by the gun-boats, to whom the fort surrendered.

At Fort Donelson, a week later, the fighting qualities of the iron-clad gun-boats were put to even a severer test than the one just mentioned. The position of the Confederate batteries, 30 odd feet above the river, gave them a plunging fire upon the gun-boats. Their armament was 12 guns, principally 32-pounders. The fight opened at a mile range and was continued down to 400 yards, and lasted an hour and a half—four iron-clads taking part. The wheel of the flag ship and the tiller-ropes of another were shot away about the same time, and both boats drifted helplessly out of action, which practically ended the attack. The flag-ship was struck 59 times, and all were well battered. The armor-plates were badly cracked and broken in places, but the armored portions of the vessels were nowhere penetrated. The pilot-houses suffered the most; the flag-officer was severely and four pilots mortally wounded, or killed outright.

A month after the Western gun-boats had had their test of battle came the first fight of the iron-clads. It was the first recorded instance wherein we have the spectacle of two armored war-ships meeting in battle. It was turret against casemate. In it the 8-in. turret armor of the *Monitor* was pitted against the 4-in. inclined armor of the *Merrimac*. In armament, the two 11-in. Dahlgrens of the one were opposed by the 10 guns—six 9-in. and four 6 and 7-in. converted Brooke rifles—of the other. The *Monitor* fired 43 rounds during the engagement against perhaps twice as many by her antagonist. Although fought almost muzzle to muzzle, no permanent injury was inflicted upon either side. The report of the *Merrimac* says that the marks of 97 shot were found on her casemate; that six of the top layer of plates were broken—none of the lower layer—and that the backing was uninjured. The *Merrimac* had received the broadsides of the *Congress* and *Cumberland* at close range, as well as several from the *Minnesota*. But while the armored portions had received little injury, everything outside was destroyed. The smoke-stack, steam-pipes and an anchor were shot away, together with railings, boat-davits and the like. A loss of 21 killed and wounded was reported. The *Merrimac* fired shell principally, from which it appears that there was no expectation, when she went out, that she would be called upon to engage anything but wooden vessels.

The *Monitor* was struck by 21 shot, seven of which were upon the turret. The only serious casualty was that to Captain Worden, in the pilot-house. Her projectiles were 168 lbs. solid shot. Some hammered wrought-iron pro-

jectiles had been provided, but they had been hurriedly finished and, owing to fear of jamming, were not used. The small damage inflicted upon the casemate of the *Merrimac* is in a great measure explained by the fact that with her 168 lb. projectiles a charge of only 15 lbs. of powder was used, giving a striking energy of but about 1,300 foot-tons. These guns were afterward fired with double this weight of powder.

(TO BE CONTINUED.)

AN ITALIAN PASSENGER LOCOMOTIVE.

THE accompanying illustrations, which are taken from the London *Railway Engineer*, show an engine and tender which were exhibited at Paris last year by the Southern Railroad Company of Italy, and which were built at that company's works in Verona. The engine was designed by Sr. Commendatore Saverio Agazzi, Chief Locomotive Superintendent of the road, and built under the superintendence of Sr. Enrico Riva, Superintendent of the shops. It is one of 30 of the same pattern which have been in service for a year or more on the Adriatic Division of the road.

The principal point to be noted is that in all the more important respects the engine is of the American type. The four-coupled drivers, the four-wheel truck, the outside cylinders with the steam-chests on top, the shifting link and the valve-rods worked from a rocker-shaft are the distinctive features of the engine, and the truck itself is of the swinging-bolster type.

In the accompanying illustrations the first is a general view of the engine and tender; fig. 2 is a longitudinal section of the engine; figs. 3 and 4 are each half horizontal sections; fig. 5 shows the front end, one-half in elevation and one-half in section; fig. 6 shows the back end, also one-half in elevation and one-half in section; fig. 7 is a cross-section showing the arrangement of the rocker-box,

EXPRESS PASSENGER LOCOMOTIVE, SOUTHERN RAILROAD OF ITALY.

FIG. 5.

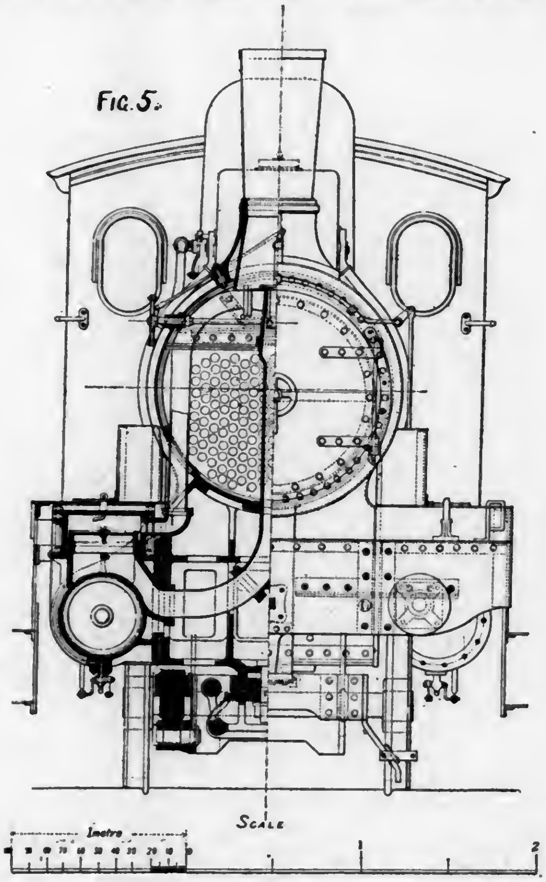


FIG. 6.

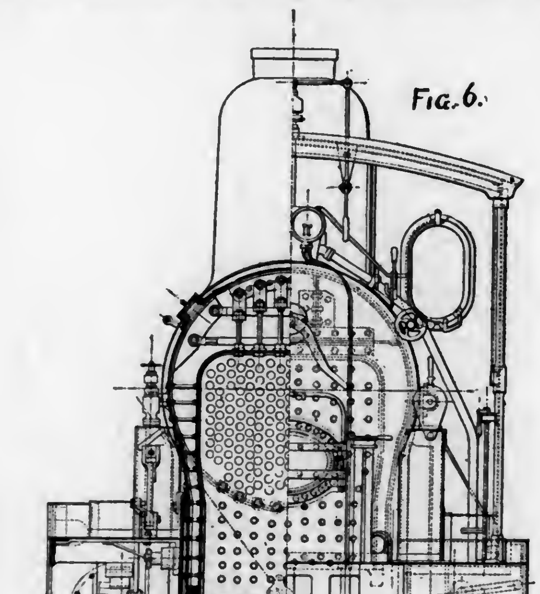
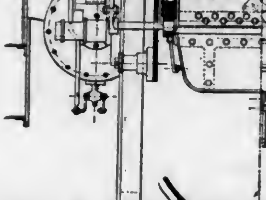
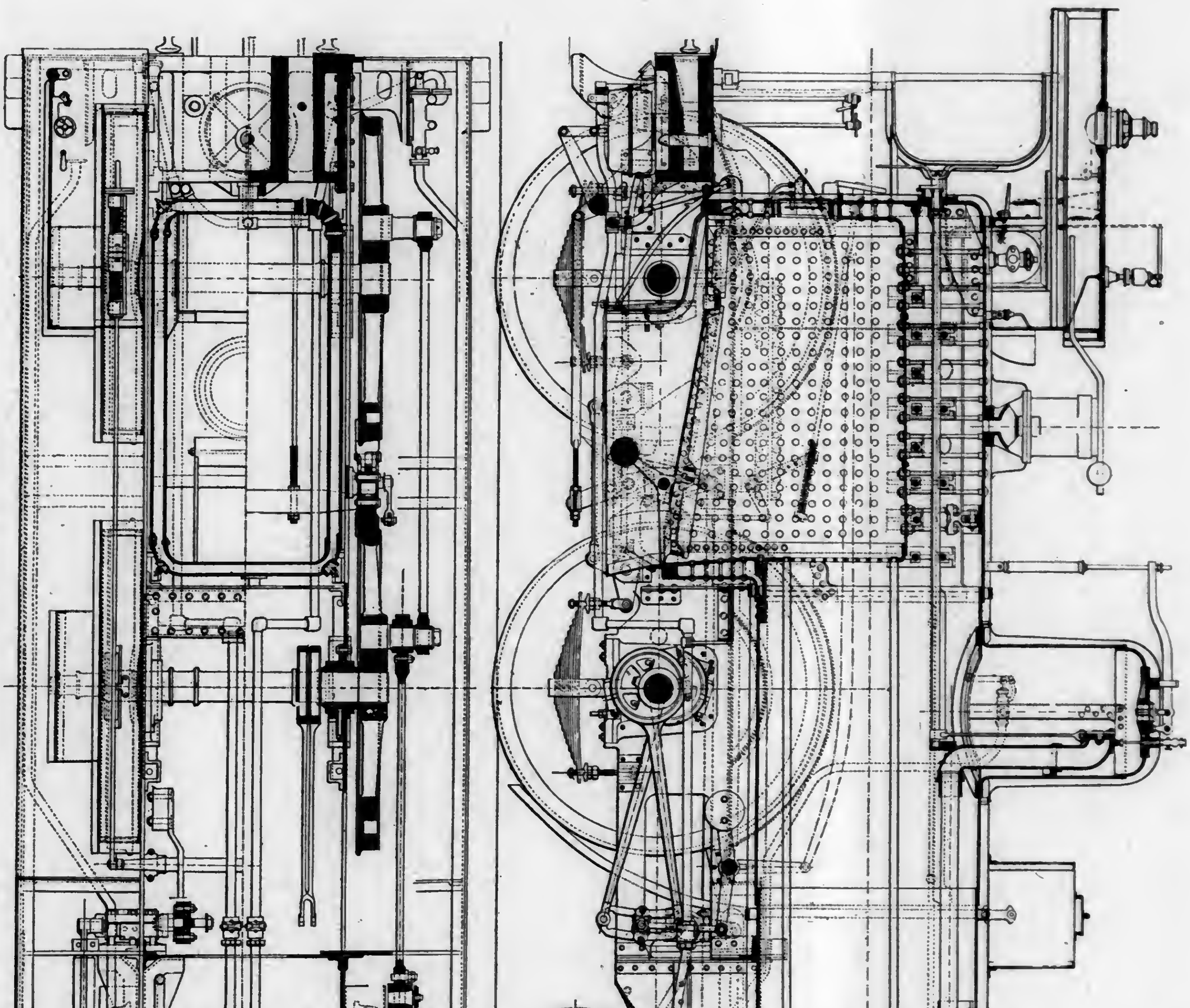


FIG. 7.





EXPRESS PASSENGER LOCOMOTIVE, SOUTHERN RAILROAD OF ITALY.

etc., and fig. 8 a section of the cylinder and steam-chest showing the valve-rod and rocker.

The boilers of these engines are large, as the division of the road upon which they run has many heavy grades, while the through trains are run at a high speed. They are 51.2 in. diameter of barrel and 12 ft. 0.3 in. in length. There are 181 tubes 1.97 in. outside diameter and 11 ft. 9.7 in. in length. The outer shell of the boiler is of steel and the fire-box of copper.

The cylinders are 17.9 in. diameter and 23.6 in. stroke. The steam-ports are 1.18 × 13.8 in. in size and the exhaust-ports 2.36 × 13 8 in.; the maximum travel of the valve is 5.12 in. The driving-wheels are 6 ft. 3.6 in. in diameter, and the driving-axle bearings are 7.1 × 9.1 in. The truck wheels are 3 ft. 1.4 in. in diameter and the truck axle bearings are 5.5 × 8.7 in. The distance from the center of

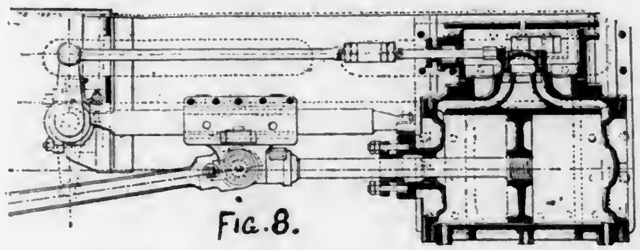


Fig. 8.

the truck to the center of the forward driver is 10 ft. 0.7 in.; the driving-wheels are 7 ft. 11.7 in. between centers, and the truck wheels are 6 ft. 3.7 in. apart between centers. The total weight of the engine in working order is 43½ tons, of which 28 tons are carried on the driving-wheels and 15½ tons on the truck. The driving-wheels are equalized in the American style.

The tender is carried on three pairs of wheels 44.1 in. in diameter. The capacity of the tank is 4,933 galls. of water, and about 4½ tons of coal can be carried. The weight of the tender loaded to its full capacity is 24.9 tons.

Engines of this type have been in service on the road for some time, drawing heavy trains of from 40 to 44 axles. The express trains of this line run at an average speed of from 34 to 40 miles an hour, and at times the engines have been run up to from 50 to 56 miles an hour; at that speed they run very steadily and without jolting. They may now be considered as the standard passenger type of the road.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

VII. LUBRICANTS AND BURNING OILS.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page* 226.)

In the articles of this series which have preceded, the following kinds of oil, for lubrication and burning, have been described—namely, tallow, extra lard oil, extra No. 1 lard oil, 150° fire-test burning oil, 300° fire-test burning oil, paraffine oil, well oil, and 500° fire-test oil. These eight products are received from the manufacturers direct, in larger or smaller shipments. They are all commercial articles, and their methods of manufacture, together with their peculiarities and the precautions necessary to be made use of in order to get good materials, under these various names, from the market, have been described. These eight substances, however, are not all used in the service in the same condition in which they are received from the manufacturers. Some of them are used just as we receive them; others are made into mixtures, and it is the object of this article to describe the use of these various lubricating and burning oils, in accordance with the present practice of the Pennsylvania Railroad.

First, in regard to burning oils. Three of the eight products mentioned above are used for burning purposes—namely, 150° fire-test burning oil, 300° fire-test burning oil, and extra lard oil. The 150° fire-test burning oil, and the 300° fire-test burning oil, are used alone for burning purposes. The extra lard oil is not used alone for burning, under any circumstances, although up to within a few years some portions of the road have used this oil as signal oil. At present mixed with 300° fire-test burning oil and 150° fire-test burning oil, it forms what is known as Signal Oil. Mixed with 300° fire-test burning oil alone, it is known under the name of Navy Sperm Oil. This makes four oils used for burning. The following explanations may be made in regard to each of these oils.

1. *The* 150° *Fire-test Burning Oil.*—This oil is used in headlights, in switch signal lamps, both high and low, in semaphore signal lamps, at the block signal towers, in torches, and also for lighting ticket and other offices and stations not otherwise provided for. It is also used, as will be described below, as a constituent of the signal oil. In headlights, the ordinary headlight burner without a button is used. In switch signal lamps what is known as the thin-wick burner is used, and this same burner is also used somewhat for semaphore signals. For torches, the standard torch burner is used, and either the No. 1 or No. 2 Sun burner, or their equivalents, or the Argand burner are used in all other places with this oil.

2. *The* 300° *Fire-test Burning Oil.*—This oil is used most largely for lighting passenger cars, and is also used, as will be described below, as a constituent of the signal and navy sperm oils. As has already been hinted in one of the previous articles, it is hoped that sooner or later 300° burning oil will be used in every place where 150° burning oil is now used, thus securing greater safety than is characteristic of the present practice. The difficulty in the way of using 300° fire-test burning oil universally is at present a question of burners and wicks. The ordinary burner and wick, which burns the 150° fire-test burning oil with perfect success, does not work well with 300° oil alone. Progress, however, is constantly being made in this line, and it is entirely possible that before many months 300° fire-test oil may be used to the almost entire exclusion of 150° oil.

3. *Signal Oil.*—This is one of the most important oils used on a railroad. What is known as signal oil is universally the oil for the hand lanterns, and on the Pennsylvania Railroad the rear-end signal lanterns on passenger trains use the same oil. A large number of experiments have been made to get a good mixture which will be perfectly satisfactory as a signal oil. At present the signal oil on the Pennsylvania Railroad is made of four parts extra lard oil, five parts 300° fire-test burning oil, and one part 150° fire-test burning oil. The flashing point of this oil is about 221° Fahrenheit, and the burning point about 270°. The old signal oil, which was used with great success for many years on most of the railroads of the country, was a mixture of two parts extra lard oil and one part 150° fire-test burning oil. Later it was found that a percentage of 300° burning oil could be introduced into the mixture with no detriment so far as light and burning were concerned, and some roads, we believe, have used a mixture of extra lard oil and 300° fire-test oil alone. It will be observed that a percentage of 150° fire-test burning oil is retained for the present in our signal oil mixture.

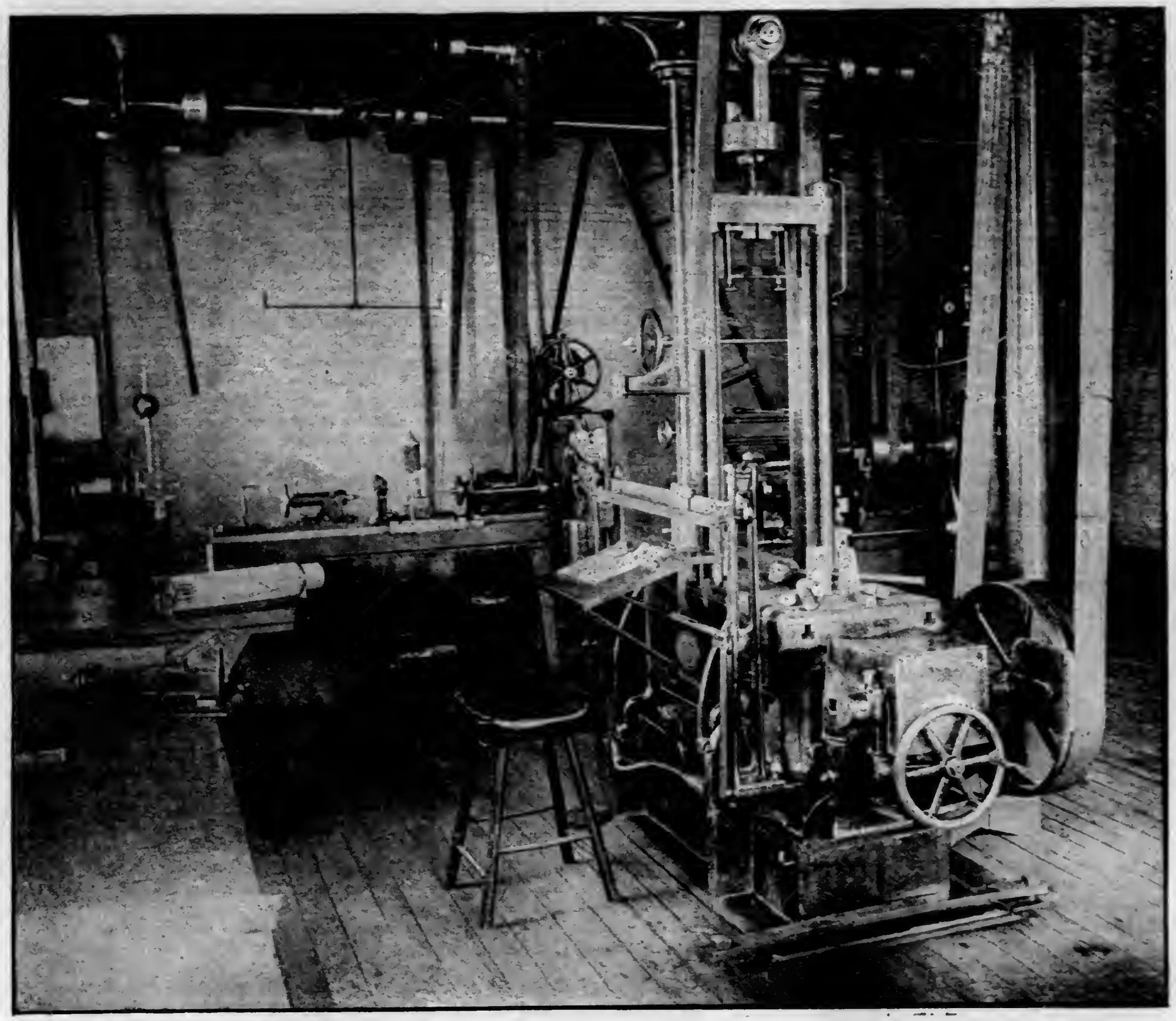
* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the Journal for December, is on the Work of the Chemist on a Railroad; No. II, in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these Contributions to Practical Railroad Information of special value in indicating the true character of the materials they must use and buy.

There are certain advantages connected with this percentage of 150° oil—namely, a better cold test and a little freer burning, with less tendency to smoke than would be obtained if the 150° oil was removed completely. Our experiments indicate, however, that it is quite possible to have a very successful signal oil without any 150° burning oil in it, and should the use of the 150° oil for this purpose be abandoned, as is hinted at above, there would really be no difficulty introduced, so far as the signal oil is concerned. The burner used with signal oil is simply a tube, holding a very loosely woven wick. The more tightly woven wick used for the petroleum products is not applicable to signal oil, apparently on account of its viscosity. The tube is usually fitted with slots for picking up the wick instead of the wheel arrangement which is common with the petroleum products. Many efforts have been made to introduce the wheel arrangement on hand lanterns, but the wick that gives best results with signal oil is so soft and loosely woven that difficulties frequently arise in attempting to use the wheel arrangement for adjusting the wick in hand lanterns. We know that some roads use them, but we have never felt willing to recommend them on account of the tendency to substitute the petroleum wick for the regular signal oil wick, to avoid the difficulty above mentioned.

4. *The Navy Sperm Oil.*—This oil, which is used on the floating equipment, differs from signal oil simply in being made of half extra lard oil and half 300° fire-test burning oil. It is used in hand lanterns and petticoat lamps on the floating equipment, in the same way that signal oil is used on land. The reason for the existence of this oil is, that the laws of certain States do not allow less than a 300° fire-test burning oil to be used on the floating equipment. This oil works charmingly with the same kind of wick and burner as is used with signal oil, and as has already been stated two or three times, it looks as though ultimately a mixture similar to navy sperm oil will become the burning oil for hand lanterns, and in lamps throughout the whole road.

The difficulties arising in the service from the use of the various kinds of burning oil during the past 15 years have been carefully investigated, and a study of almost each individual case has been made. Moreover, the interests involved in signals are so tremendous, it has been felt that any amount of study and care was not too great to secure an oil which would give perfectly reliable and satisfactory results. Some two or three years ago the results of the investigation of all the cases of signals which had failed or given difficulty in service were brought together, and a circular of instructions to the men drawn up embodying the results above referred to, and giving instructions as to how to avoid these difficulties in future. This circular is given in full below, and since its issue the complaints in regard to failure of signals and difficulties with the lamps have diminished quite largely. The following is the circular :



PHYSICAL TESTING ROOM OF THE PENNSYLVANIA RAILROAD LABORATORY, ALTOONA.

etc., and fig. 8 a section of the cylinder and steam-chest showing the valve-rod and rocker.

The boilers of these engines are large, as the division of the road upon which they run has many heavy grades, while the through trains are run at a high speed. They are 51.2 in. diameter of barrel and 12 ft. 0.3 in. in length. There are 181 tubes 1.97 in. outside diameter and 11 ft. 9.7 in. in length. The outer shell of the boiler is of steel and the fire-box of copper.

The cylinders are 17.9 in. diameter and 23.6 in. stroke. The steam-ports are 1.18 × 13.8 in. in size and the exhaust-ports 2.36 × 13.8 in.; the maximum travel of the valve is 5.12 in. The driving-wheels are 6 ft. 3.6 in. in diameter, and the driving-axle bearings are 7.1 × 9.1 in. The truck wheels are 3 ft. 1.4 in. in diameter and the truck axle bearings are 5.5 × 8.7 in. The distance from the center of

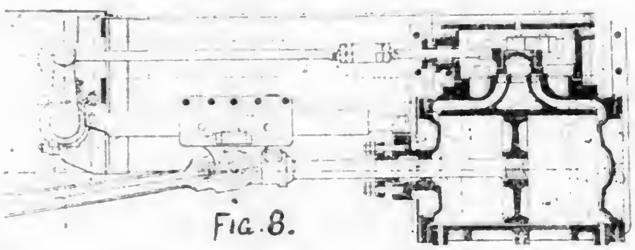


FIG. 8.

the truck to the center of the forward driver is 10 ft. 0.7 in.; the driving-wheels are 7 ft. 11.7 in. between centers, and the truck wheels are 6 ft. 3.7 in. apart between centers. The total weight of the engine in working order is 43½ tons, of which 28 tons are carried on the driving-wheels and 15½ tons on the truck. The driving-wheels are equalized in the American style.

The tender is carried on three pairs of wheels 44.1 in. in diameter. The capacity of the tank is 4,933 galls. of water, and about 4½ tons of coal can be carried. The weight of the tender loaded to its full capacity is 24.9 tons.

Engines of this type have been in service on the road for some time, drawing heavy trains of from 40 to 44 axles. The express trains of this line run at an average speed of from 34 to 40 miles an hour, and at times the engines have been run up to from 50 to 56 miles an hour; at that speed they run very steadily and without jolting. They may now be considered as the standard passenger type of the road.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

VII. LUBRICANTS AND BURNING OILS.

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page 226.*)

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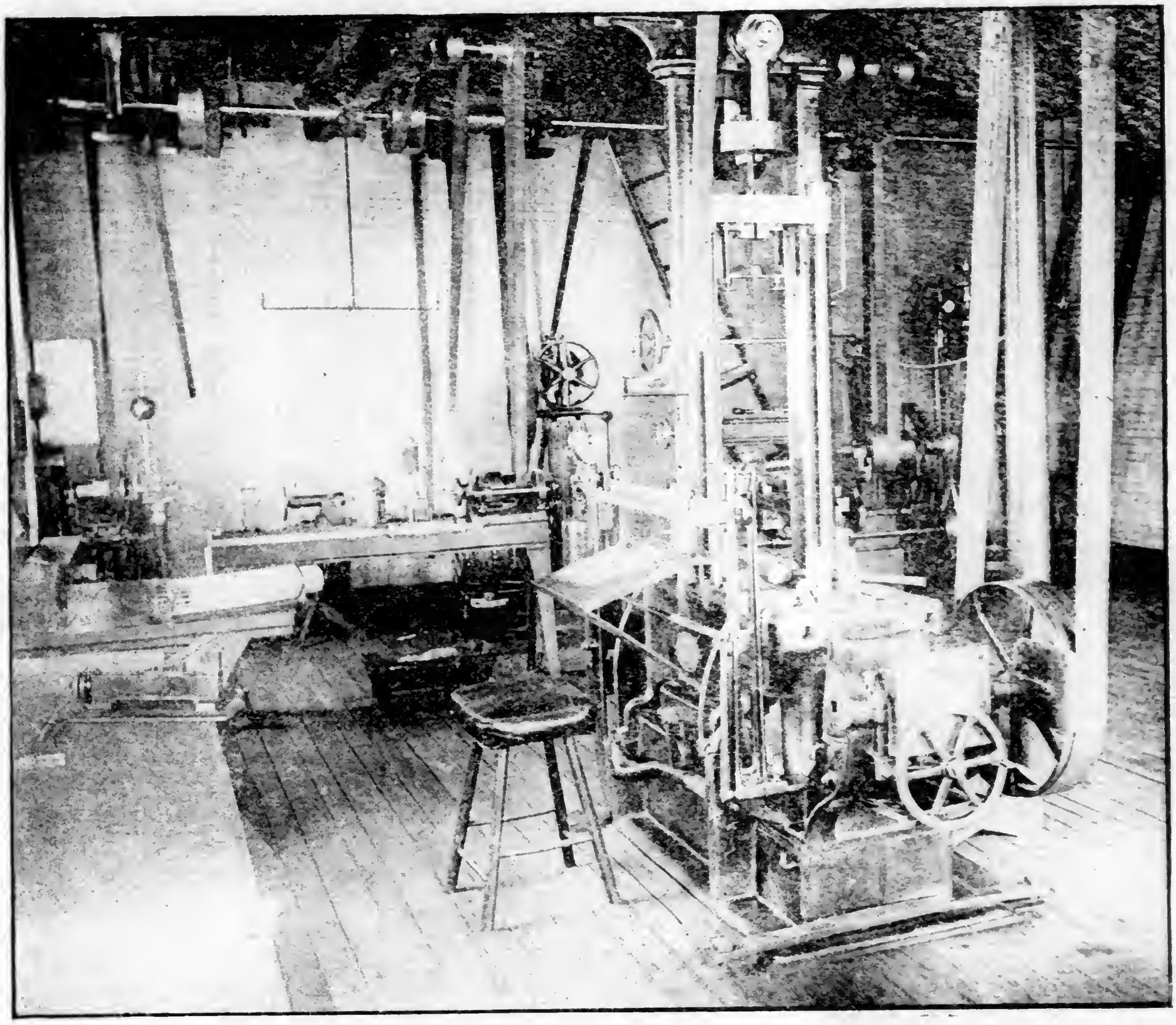


PHYSICAL TESTING ROOM OF THE PENNSYLVANIA RAILROAD LABORATORY, ALTOONA.

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Information and Instructions in Regard to Burning Oils and the Care of Lamps.

The oils used for burning are :

1. 150° Fire-test Oil—Known also as "Head Light Oil" and "Carbon Oil." The "Kerosene Oil" of market is the same in kind, only lower in fire test, and cannot be used in place of 150° oil.

2. 300° Fire-test Oil—Known also as "Mineral Sperm," "Mineral Seal." "Golden Light," and "Sunlight" oil.

3. Signal Oil—Which is a mixture of extra lard oil, 150° oil and 300° oil.

4. Navy Sperm—Which is a mixture of extra lard oil and 300° oil.

The 1st and 2d are petroleum, and the 3d and 4th fatty burning oils.

THE 150° FIRE-TEST OIL.

A tightly woven compact wick should be used.

It will burn successfully with any good burner that has a chimney, either Dual, Argand, or any of the numerous kerosene oil burners of the market ; it also burns well with a wick as above in a number of no-chimney burners to be found in the market ; it gives satisfactory results without a chimney, with the thin-wick burner, but in this case a special thin wick adapted to the burners must be used. It works well also in torches with any good torch wicking.

THE 300° FIRE-TEST OIL.

The same kind of tightly woven compact wick as described for 150° fire-test oil should be used.

It always requires a chimney, and either the Dual or the Argand burner ; it works best with the Dual, is less satisfactory with the Argand, and gives very poor results with the ordinary kerosene oil burners.

THE SIGNAL AND NAVY SPERM OIL.

A loosely woven wick should be used.

Neither will burn successfully with the tightly woven compact wicks used with the petroleum oils. The wicking best adapted to fatty burning oils is known in the market as No. 1 lard oil wicking.

Neither requires a chimney and the burners need be little more than tubes, in which the wick fits closely enough to maintain itself in place, having slots for adjustment.

The tubes may be round or flat, and the hand wheel or pinion used in adjusting the wicks of petroleum burners should not be used.

Any of these four oils may give bad results from the following causes :

1. *Clogging of the wick.*—There may be two causes for this—1st, it is impracticable to keep either the lamps or the oils, before they are put into the lamps, free from fine particles of dust and dirt, and the wick being a filter, sooner or later becomes clogged with this dust and dirt. 2d. All the oils undergo slow changes by exposure to the light and air, which seem to result in the formation of tarry or gelatinous matter which clogs the wick and prevents it from doing its work satisfactorily.

2. *Wicks fitting too tightly or too loosely in the tube.*—The effect of the wick being too tight is to prevent the oil flowing to the flame, and if too loose it frequently jars down and diminishes or extinguishes the light.

3. *Use of the wrong wick.*—The closely woven compact wick will not burn signal oil or navy sperm oil successfully, and should not be used with them.

The loosely woven wick will burn the petroleum oils successfully, but its loose texture gives much difficulty with the hand wheel or pinion used with the compact wick, so that it is not advisable to use it with the petroleum oils.

4. *Wicks of inferior quality.*—This is of very rare occurrence.

5. *The oil being too old.*—This may occur with any of the four oils mentioned. It is least likely to cause trouble with 150° oil, rather more so with 300°, but signal oil and navy sperm oil often give difficulty from this cause. The petroleum oils six months old rarely give serious difficulty, but the fatty oils three months old will almost certainly give trouble. This is true of the oil in the lamp as well as of the oil in cans or barrels. Where lamps are little used the age of the oil is not unfrequently the cause of trouble. When lamps are filled with fresh oil, and burned every day, the difficulty due to old oil is greatly diminished, but all lamps sooner or later will give difficulty from this cause.

6. *Different oils mixed in the same lamp.*—A small amount of 150° oil mixed with either of the other oils will cause no difficulty ; a large amount would make 300° oil more dangerous, but would not seriously affect it otherwise. It would cause the signal oil and navy sperm oil to smoke badly, and make them both dangerous to use.

A small amount of 300° oil mixed with 150° oil would diminish the light, and a larger amount would have the same effect in a greater degree. A small amount of 300° oil added to either signal oil or navy sperm oil would have very little effect. A large amount would make both of them smoke, and would increase the danger of these oils.

A small amount of either signal oil or navy sperm oil mixed with either 150° or 300° oils is a very serious matter. The light diminishes and the wick begins to crust at once, and no further satisfactory results can be obtained from that lamp until the oil in the lamp has been thrown away, the lamp and burner thoroughly cleaned, and a new wick and fresh oil of the right kind put in the lamp. A large amount of signal oil or navy sperm oil with either of the petroleum oils increases the difficulty, and indeed may cause the light to go out entirely.

Mixing signal oil and navy sperm oil in the same lamp is followed by no serious difficulties, but signal oil should never be mixed with navy sperm on the floating equipment.

7. *Congealed oil in lamps.*—This difficulty occurs with the fatty oils, and occasionally with 300° oil. The 150° oil rarely gives trouble from this cause. When this difficulty occurs it is evident either that the lamp is not sufficiently well protected, or that an attempt has been made to use an oil unadapted to the situation. The navy sperm oil congeals so as to give trouble at 50° Fahrenheit, the signal oil at 40° Fahrenheit, the 300° oil at 25° Fahrenheit, and the 150° oil in general at zero Fahrenheit, although some shipments are perfectly clear at 20° below zero Fahrenheit. As more or less heat is always conveyed from the burner to the lamp, it is probable that all of these oils can be used in situations from 10 to 20 degrees lower than the figures above given. Many devices have been used for keeping the oil in exposed lamps fluid, most of which depend on utilizing some of the heat from the burner for this purpose. It is best to use always an oil which will not congeal in the situation, or to protect the lamp so that the oil will not congeal ; but if from any cause oil must be used which congeals in the situation, it is advisable to use some of the devices above referred to.

8. *Cloudy oil.*—This occurs mostly with the petroleum oils, but may also happen with the fatty oils. In the fatty oils the cloudiness is due to finely suspended dirt or dust, or to gluey or gelatinous matter which comes originally from the lard oil used in compounding signal and navy sperm oils. In these oils the cloudiness will generally disappear if the oil is allowed to settle. In the petroleum oils the cloudiness is generally due to gluey matter from the inside of the barrels, put in to make the barrels tight, or possibly to watery sedimentary matter left in the oil at the works during the process of purification. Both these difficulties are due to carelessness at the oil refineries, but their effects are most disastrous. A lamp in perfect order, filled once or twice with cloudy 150° or 300° oils, will ever after give unsatisfactory light, no matter how much good oil is subsequently added, until the wick and cloudy oil in the lamp are thrown away, the lamp cleaned, and a new wick and fresh, good oil supplied. Cloudy petroleum oils probably occasion more difficulty in lamps than any other single cause.

9. *The oil level too far away from the flame.*—This is a fault in the construction of the lamp and burner more than anything else, though the texture of the wick has an influence.

It is desirable to have lamps in which the oil level cannot become, even when the lamp is nearly empty, more than 5 in. from the bottom of the flame for 150° oil, 4 in. for 300° oil, and 3 in. for the fatty oils. In general an effort should be made by frequent filling to keep the oil level as near the bottom of the flame as possible, but this should not be construed as permitting a lighted lamp ever to be filled.

10. *Miscellaneous causes.*—It is not necessary to remark upon the difficulties which may arise from such obvious causes as "burner out of repair," "burner tube choked with crust," "no oil in the lamp," "want of trimming," "dirty chimneys," "wick too short to reach the oil level," or "lamp so situated that it blows out."

Whenever a lamp gives unsatisfactory light, proceed as follows :

1. If the difficulty arises from any of the causes mentioned in Section 10 above, apply the appropriate obvious remedy.

2. If the oil is congealed, use a different oil, protect the lamp better, or use some device to keep the oil fluid.

3. If the wick is of the wrong kind, too tight or too loose, change it.

4. Put in a new wick which will remove the difficulty if it is due to the old wick having become clogged.

5. If none of the above directions remove the difficulty, burn the oil down low, throw away the wick and the oil left in the lamp, and also the oil supply in the can, clean the lamp, burner, and can thoroughly, and start afresh with a new wick and new oil.

6. If the difficulty still continues, shake the oil-can thoroughly, pour out a little of the oil into a glass bottle, and see if it is cloudy. If so send a bottle of it to the Superintendent Motive Power for examination. At the same time, get a new supply of clear oil, also burn the oil down low, throw away the oil and wick, clean the lamp and start afresh with clear oil.

7. As a final resort, send the lamp, the wick, and, if possible, not less than a quart of the oil to the Superintendent Motive Power, with a letter stating what the difficulty is, and where the oil and wick were obtained.

All persons in charge of oil supplies will be held strictly responsible for giving out into the service any cloudy oils. Signal oil and navy sperm oil should always, if possible, be held in tank long enough to settle clear. If this is not possible it should all be filtered through heavy canton flannel. As soon as a shipment of 150° or 300° oil is received each barrel should be rolled about, so that the oil is thoroughly mixed, and then a sample examined to see if the oil is cloudy. All barrels containing cloudy oil must be set aside and not used.

APPROVED: JUNE 13, 1887.

THEODORE N. ELY,
General Superintendent Motive Power.

Second, in regard to lubricating oils, the five other products mentioned above—namely, the extra No. 1 lard oil, paraffine oil, well oil, 500° fire-test oil, and the tallow are used for lubrication, some of the materials being used pure and simple as we receive them, and others mixed. The extra No. 1 lard oil is not used alone for lubrication except in special cases. On fast passenger trains it is sometimes used in the car boxes, and sometimes also in the very hot weather it may be used alone as engine oil on locomotives. The tendency of the practice during the past few years has been, however, toward using some sort of a lubricating grease instead of extra No. 1 lard oil on the fast passenger trains. The principal use of extra No. 1 lard oil is as a constituent of engine oil, as will be described below.

The well oil is used exclusively for freight car lubrication in the car boxes. In certain portions of the service it may be used likewise on passenger trains in the boxes, and also in passenger and freight engine tender trucks. It is also used for miscellaneous greasing in the foundries, and also in making passenger car oil for a portion of the passenger car equipment.

The engine oil is at present a mixture of half extra No. 1 lard oil and half paraffine oil. This is, perhaps, the most important lubricating oil used on the road. It is used on all engine machinery, in engine and tender truck boxes, except as previously specified in certain portions of the service. It is used on shafting everywhere in the shops, for machine tools, bolt cutting, and for general lubrication everywhere except passenger and freight cars. Many experiments have been made with mixtures of lard and paraffine oils to arrive at the best results. At one time mixtures of two-thirds lard and one-third paraffine oil were used on passenger engines, and one-half lard and one-half paraffine oil on freight engines. Again, a summer engine oil and a winter engine oil were made, the winter engine oil differing in having a larger percentage of paraffine oil on account of the cold test. Furthermore the market has frequently furnished different grades of paraffine oil, with the claim that more of this special paraffine oil could be used in making engine oil with economy, since the paraffine oil is much cheaper than lard oil. Many experiments have been made on this point, some of which seem to indicate that an engine oil of three-quarters paraffine oil and one-quarter extra No. 1 lard oil would work satisfactorily. All these mixtures, however, have produced no permanent change in the engine oil mixture, which has been used as above stated for now some 10 years or more without change. Certain portions of the service, especially those having lighter pressures, could use a larger percentage of paraffine oil, and also certain portions of the engine service could use an oil with a larger percentage of paraffine oil in it; but the introduction of a large number of oils, differing from each other in the proportions of their constituents, introduced such difficulties into the service that all attempts to produce these very small economies have been abandoned, and one engine oil is used for all general lubrication. The difficulties of having a number of different kinds of lubricating oils, differing in proportions of the same ingredients, are liability of confusion in using the various oils, since they cannot be identified by simple inspection, and the complications which arise from the necessity of keeping a number of oils in stock at each place where they are given out to the service.

There are certain peculiarities in the service which this uniform grade of engine oil does not cover to perfect satisfaction—namely, extremes of hot and cold weather. In the extreme hot weather the engine oil is a little too limpid for crank-pins, although working well in other places, and in the extreme cold weather, although a cold test is enforced as severe as the ingredients will bear, the engine oil is frequently too stiff for satisfactory service. Both these emergencies are met when they arise on the engine. Every engineer carries a little tallow or a little extra No. 1 lard oil for the hot weather emergencies, and for the cold weather emergencies it is not at all uncommon to mix headlight oil with the engine oil. It is deemed advantageous to have these emergencies met by the engineers as they arise rather than to attempt to furnish an oil which would meet the requirements, and would at best, perhaps, only be used a few days at a time. So successful has the engine oil on the Pennsylvania Railroad been, that any attempts to change the oil meet with considerable opposition from the service. We really would hardly know how to make a single oil for general lubrication everywhere which would meet the requirements better than the above mixture.

The passenger car oil, which is not universally used for passenger cars, is a mixture of one-third extra No. 1 lard oil and two-thirds well oil. Many of the branch roads, and indeed some portions of the main line, use well oil in passenger car boxes with perfect success, and where the speed is not above 25 to 30 miles an hour there seems to be very little difficulty with common well oil in the passenger car boxes. Where the speed is higher than this, and especially where there are frequent trains, causing much dirt, something rather better seems to be required, and for this purpose the passenger car oil was devised. It is almost as good as the extra No. 1 lard oil, and when it was first used in many places took the place of extra No. 1 lard oil.

For cylinder lubricant the practice of the road is quite varied. In some places tallow alone is used. This practice, however, is being abandoned, and it seems probable that within a year tallow alone will not be used anywhere. At present its use is confined almost exclusively to places where facilities for mixing the lubricant do not exist. In all places where facilities for mixing do exist the standard lubricant for locomotives not fitted with sight-feed cups is two parts tallow and one part 500 fire-test oil. This lubricant is used in the intermittent way, in the old-fashioned tallow cups or through tallow pipes from the cab. In all cases where engines have been provided with sight-feed cups the standard cylinder lubricant is three parts 500° fire-test oil and one part extra lard oil. Also on stationary engines and on the marine equipment in steam cylinders 500° fire-test oil alone is used as cylinder lubricant. The experience of the road indicates that where tallow has been used as cylinder lubricant, it is unwise to pass immediately from tallow to a lubricant containing a large percentage of petroleum products The reason for this is that the tallow contains free acid, as has already been described, which acts on the iron of the cylinders and valves, forming an iron soap which remains in all the crevices. The petroleum dissolves this, and if it is dissolved in large quantities at one time it causes the valves and pistons to stick and makes the friction very great. In passing from tallow to any cylinder lubricant containing large quantities of petroleum, the change should be made slowly. A mixture of two parts tallow and one part 500° fire-test oil should be used for a few months, and then perhaps the standard lubricant for sight-feed cups could be used with success. Many experiments have been made to see if the petroleum products alone

would not be satisfactory as locomotive cylinder lubricant, and while it is hoped that possibly as time progresses the amount of lard oil used in the standard locomotive cylinder lubricant with sight-feed cups may be diminished, no experiments yet have been successful in which a 500° fire-test oil alone was used. The reason why extra lard oil is used in making cylinder lubricant is because it contains much less free acid than the extra No. 1 lard oil, and very great care is taken not to use extra No. 1 lard oil in making this lubricant.

For the sake of completeness we may add that in the shops, on machine tools, an emulsion of sal soda, water, and oil is used, the idea being that the water serves to keep the cutting tool cool, while the oil serves to lubricate it. This emulsion is called "Soda Mixture for machine tools," and is made by dissolving 5 lbs. of sal soda in 40 gallons of water and stirring thoroughly. When needed for use about half a pint of engine oil is put in a suitable vessel and a gallon of the soda mixture added, and the two mixed thoroughly. This material works very nicely, and is used over and over again. Small tin cans fitted with faucets and tubes are used for feeding it to the tool in a rather free stream, and pans underneath the machines, which catch the chips, also catch the liquid, which may be used more than once.

It will be observed that there are some 15 oils used for burning and lubrication, of which eight are obtained from the market and seven are mixtures made by the railroad companies for their own use; four of the 15 are used for burning and 11 for lubrication.

Notwithstanding the amount of work that has been put on lubricants and burning oils, and notwithstanding the standard practices which have been described either above in this article or in the previous articles, the subject is not regarded as exhausted. Constant study is being put on possible modifications of the lubricants and burning oils which will result in greater efficiency and at the same time greater economy. With the increase of speeds and pressures, which is characteristic of modern progress in railroading, the lubrication problem is becoming more and more difficult, and it seems probable that modifications in the lubricants will be necessary as time progresses. Also with higher speeds the signal lamps used on engines will give greater difficulty, and it is entirely possible that modifications in burning oils to meet this difficulty may be required.

In the next article of this series we will describe the method of purchasing oils in use, and also have something to say about hot-box and lubricating greases.

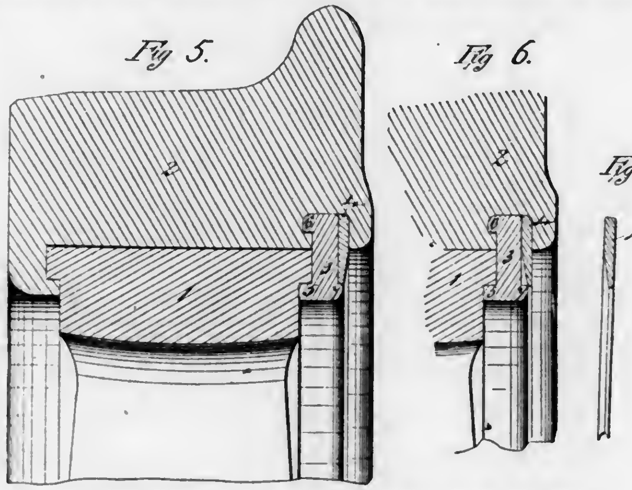
(TO BE CONTINUED.)

Recent Patents.

I.—METHOD OF FASTENING TIRES.

FIGS. 5, 6, and 7 show a method of fastening tires, for which Patent No. 415,745 was granted, under date of November 26, 1889, to William Stroudley, of Brighton, England. It is described by the inventor as follows: "This invention has for its object to dispense with or reduce the hammering of the tire, which has been usual according to the method of attachment, thus obviating the risk of fracture and enabling a much harder and more durable steel tire to be employed. To this end a ledge, shoulder, or check is formed on the outside of the inner or clip-ring, near its inner circumference. This inner or clip-ring is secured in position by means of a wedge or lewis-ring, which is either cut across and sprung in behind the inner or clip-ring or is inserted in two or more parts, filling the vacant space in the groove formed in the tire to receive the clip-ring. The wedge or lewis-ring is beveled or chamfered for a portion of its breadth at its inner side, and when in position is laid down by a hammer, by which its chamfered side is applied closely to the clip-ring, and its inner edge is made to surround the ledge, shoulder, or check formed on the clip-ring. The lewis-ring is thus prevented from leaving the groove, while at the same time it secures the clip-ring accurately in place without being made of the taper form within the groove, as heretofore. This construction gives an additional support or buttress should the tire break into short pieces, and prevents the edge of the clip-ring from leaving the rim of the wheel. Both rings may be made of mild steel, the lewis-ring being somewhat softer than the clip-ring, so that it may be laid down with a hammer into its place. This hammering will of itself stiffen and harden the ring. Thus the flange or clip of the tire itself will not require to be struck with a hammer, as with the construction hereinbefore referred to, or if at all only very lightly.

"There are several ways of getting both the clip-ring and the lewis-ring into position. One way is to make across the ring a



STROUDLEY'S METHOD OF FASTENING TIRES.

cut and to chamfer the ends at each side of the cut to admit of springing the ring into place. Another and a better way is to cut out of the ring a piece of sufficient length to allow the remainder to be sprung into place, the smaller piece being afterward inserted to complete the ring in place. The ring may, however, be inserted into position in several pieces.

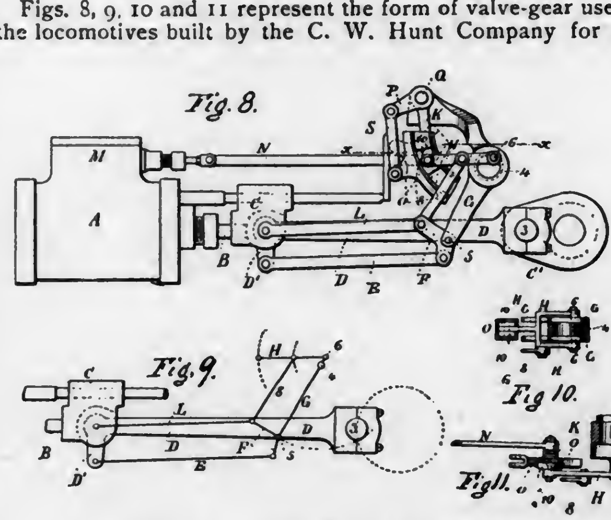
"On the accompanying sheet of drawings, fig. 5 shows in section so much of one form of a wheel-body and tire as is needful to illustrate this invention. Fig. 6 is a similar view to fig. 5, showing the lewis-ring as it appears before it is hammered or laid down onto the clip-ring as it is shown in fig. 5. Fig. 7 shows a section of the lewis-ring.

"In these 1 is the wheel rim or body; 2, the tire; 3, the clip-ring; 4, the wedge or lewis-ring.

"The clip-ring has on one side two annular lips or lugs 5 6, the one engaging with the rim or body and the other with the tire. At its opposite side it has a ledge, shoulder, or check 7. The upper portion of the clip-ring lies within a groove in the tire and is held in place by the wedge or lewis-ring 4, which is inserted into the groove behind. The wedge-ring in this example is of the shape shown in fig. 7, and when it is first put into place its beveled part occupies the position shown in fig. 6. It is then laid down into the position shown in fig. 5 and securely locks the wheel-body, the tire, and the ring 3 all together."

II.—VALVE-GEAR.

Figs. 8, 9, 10 and 11 represent the form of valve-gear used on the locomotives built by the C. W. Hunt Company for their



HUNT'S LOCOMOTIVE VALVE GEAR.

narrow-gauge roads, which were described in the November, 1889, number of the JOURNAL. This valve-gear is the invention

of Mr. Hunt, and has been patented by him, and is described in his specifications as follows :

"I make use of a connecting-rod in the form of a bent lever, the short arm of which gives a rocking motion through a link to a rocker pivoted upon a swinging radius-arm, and the valve receives its motion from a swinging link and block moving within a slotted sector.

"The special feature of the improvement relates to the combination, with the parts before mentioned, of an eccentric pivot between the swinging link and the radius-arm, whereby the radius-arm in its movement varies the position of the pivot of the swinging link sufficiently to produce the lap and lead required of the valve in the engine.

"In the drawings, fig. 8 is an elevation of the devices made use of by me, and fig. 9 is a diagram illustrative of the motions given to the respective parts. Fig. 11 is a sectional plan view below the line *x x*, fig. 8 ; and fig. 10 shows the sector made in two parts and the radius-arm as double.

"The engine-cylinder *A*, piston-rod *B*, cross-head *C*, crank *C'*, crank-pin 3 and connecting-rod *D* are of ordinary construction, and the connecting-rod *D* has a short arm *D'* at right angles to the connecting-rod itself, so that such connecting-rod and short arm form a bent lever, and there is a radius-arm *G*, having a pivot or gudgeon 4, supported by an arm upon the frame of the engine, having an eye at the end, and at the moving end of this radius-arm *G* is a rocker *F* in the form of a bent lever, one end of which is united by a link *L* directly to the cross-head *C*, and the other end is united by a link *E* to the short arm *D'* of the connecting-rod ; hence in the movement of the parts the rocker *F* swings the radius-arm *G* upon its pivot 4, and the rocker *F* is swung upon its pivot 5 at the end of the arm *G*, in consequence of the short arm *D'* of the connecting-rod having a swinging movement as the crank-pin 3 describes a circle, and the end of the connecting-rod *D* rises and falls as it moves with such crank-pin ; hence the link *H*, pivoted at 6 upon the radius-arm *G*, receives a swinging motion up and down by the link 8 between the rocker *F* and said link *H*, and in addition to the up-and-down swinging motion given to the link *H* the pivot 6 thereof describes an arc of a circle, and as the radius-arm *G* is moved it carries the pivot 6 toward and from the valve-chest *M*, for giving to the valve the lap and lead required according to the direction in which the piston is moving. The valve-rod *N* is connected to the valve within the chest *M*, and such valve may be of any desired character, and at the other end of such valve-rod *N* is a sector *O*, pivoted at or near its center to such valve-rod *N*, and this valve-rod and sector can move back and forth in line with the valve-rod, the parts being supported by a pin in a horizontal slot, or, preferably, hung by a loose link *K* from the shaft *Q*, to which shaft a reversing-lever of any desired character is to be applied, and upon the end of the shaft *Q* is a crank-arm *P* and a link *S* to an arm upon the sector *O*. In this sector *O* is a slot or curved channel, the radius of which is the same length as the swinging link *H*, and in the slot of this sector is a block 10, to which the moving end of the swinging link *H* is pivoted. If now the parts stand in the position represented by the full lines in fig. 8, the valve receives its motion from the endwise movement given to the valve-rod *N* by the block 10 being moved up and down in the curved slot of the diagonally-placed sector *O* by the swinging link *H*, which link receives its motion as before described, and the proportion of the parts is such that the center of the block 10 is in line with the connection between the sector *O* and the valve-rod *N* when the crank passes the dead-center, and as the crank rises the block 10 is moved downwardly, and by the curvature of the sector *O* the valve receives its end motion, and when the crank *C'* passes the other dead-center the block 10 is moved upwardly to give the required motion to the valve in the other direction. In both instances the radius-arm *G*, as it swings, moves the pivot 6 of the link *H* toward and from the valve-chest, and thereby the proper movement is given to the valve in addition to the motion resulting from the block 10 moving in the sector *O*, so that the proper lap and lead to the valve is the result. When the shaft *Q* and crank-arm *P* are moved by the reversing-lever, the sector *O* is swung upon its connection to the valve-rod *N*, and it assumes the reverse diagonal position indicated by the dotted lines, so that the engine will run in the other direction ; but if the reversing-shaft *Q* and crank-arm *P* are moved to an intermediate position the sector *O* is not moved by the swinging of the link *H*, because the arc of the sector *O* corresponds to the arc described by the link *H* as a radius ; but the slight movement resulting from the pivot 6 being carried toward and from the valve-chest by the movement of the radius-arm *G* will by construction equal its lap and lead of the valve, but not be sufficient to admit steam even when the momentum of the locomotive may produce a continuance of the revolution of the crank *C'* and the shaft with which it is connected, after the reversing-gear has been moved to stop the engine."

THE ESSENTIALS OF MECHANICAL DRAWING.

By M. N. Forney.

(*Continued from page* 230.)

CHAPTER III.—(*Continued.*)

ANGLES.

An *angle* is the amount of inclination of two lines to each other. Thus in fig. 40 the difference in the direction of the lines *E A B* and *A C* forms the angle *C A B*. This difference in their inclination is entirely independent of the length of the lines, and is measured on an arc of a circle drawn from the point *A*—called the *vertex* of the angle—where the two lines meet as a center. Thus suppose that any arc *f b c* is drawn from *A*. The portion *b c* of this arc between the lines *A B* and *A C* would then be a measure of the angle *C A B*. If from *b* a distance *b f* = *c b* be laid off on *c b f*, and another line, *A D*, be drawn through *A* and *f* so as to form an angle with *C A*, then *b f* would measure the angle *C A D*, and as *b f* = *b c* the angles *B A C* and *C A D* are equal, and the angle *B A D* is twice *B A C* and *C A D*. If two angles are measured by arcs, the radii of the arcs must be of equal length. It is not important, however, what the length of the radii is, so that it is the same for both arcs. Thus the two angles might be measured by the arcs *c' b'* and *b' f'* as well as by *c b* and *b f* ; but we could not ascertain the extent or degree of the inclination of the lines if we measured the one angle with an arc *c b* with a radius *c A*, and the other with an arc *b' f'* with a drawn radius *c' A*, which is of a different length.

The standard or unit of measurement of angles is based upon the division of circles into 360 equal parts called *degrees*. In writing or printing these are indicated by a small circle, thus °, and 45 degrees is written 45°. It must be understood that all circles, without reference to their size, are supposed to have 360°, and that the angles formed by lines radiating from the center of a circle of any radius will include an equal number of degrees on the circumference of a circle of any other radius drawn from the same center. Thus, in fig. 41, the circles *a b c d e*, *a' b' c' d' e'*, and *a" b" c" d" e"*, drawn from the same center, *A*, are each divided into 360 equal parts or degrees. If a line, *A B*, is drawn through the center, *A*, and the 0 or *zero* point, as it is called, of the divisions, and another line, *A C*, through *A* and *b*, the 30th division, so that the two lines form an angle, *C A B*, with each other, they will include 30 of the divisions or degrees on each of the circles. The angle *C A B* is therefore said to be an angle of 30°. If we draw another line, *A D*, through the 60th division so as to form an angle *D A B* with *A B*, then *D A B* will be an angle of 60°.*

If the circumference of any circle is divided into 360 equal parts, it will serve as a *protractor*, or instrument for measuring angles. Usually such instruments are made of a metal plate or card in the form of a half circle, which is divided in the same proportion, or into 180°, as shown by fig. 9.

Problem 9 (fig. 40). *To measure the number of degrees in an angle, as B A C, fig.* 40.

With a pair of compasses, take from fig. 41 a distance *A c* = to the radius of the outside circle, which will serve as a protractor, and with this distance as a radius, from the vertex *A*, fig. 40, of the angle *B A C* describe an arc *b c*. With a pair of dividers, take the distance from *c* to *b*, the points where the arc *b c* intersects the lines *A B* and *A C*. Then with the dividers carefully set one of its points on the 0 or zero point of the protractor at *c*, fig. 41, and measure on the circumference *c b* the number of degrees included between the points of the dividers, which will be the number in *c b*, of fig. 40, and will be the measure of the angle *B A C*. We might draw an arc *c' b'* with *A c'*, the radius of the intermediate circle in fig. 41, and then measure on its circumference from *c'* to *b'* and use it as the protractor, to get the number of degrees of the angle *C A B*, fig. 40 ; or we might take *A c"*, or the radius of the outer circle of the protractor, fig. 9, for the same purpose.

Problem 10 (fig. 42). *To lay off an angle of any number of degrees from a given line and vertex.*

If *A B* is the given line, with a radius such as *A c*, fig 41, of any protractor, from the vertex *A*, fig. 40, of the proposed angle as a center, describe an arc *c b f*. Then from the circum-

* An angle of 90°, as *e A a*, figs. 40 and 41, is called a *right angle*, and is formed when one straight line, as *a A*, is drawn perpendicular to or square with another line, as *e A B*. An *acute angle* is one having less than 90°, as *B A C* or *B A D*. An *obtuse angle* is one of more than 90°, as *e A D* or *e A C*. An *oblique angle* is any angle not a right angle.

ference of the outside circle, in fig. 41, with a pair of dividers measure the proposed number of degrees from *o*—in this case 30°—and set them off from *c* to *b* on *c b f*, fig. 40. Through *A* and *b* draw the line *A C*. *B A C* will then be an angle of 30°. In the same way *B A D*, an angle of 60°, may be laid off.

If it is required to lay off an obtuse angle, as *e A D*, fig. 40, it is usually best to draw a perpendicular, as *a A*, through the vertex *A*, which will form a right angle *e A a* with *e A b*. Then

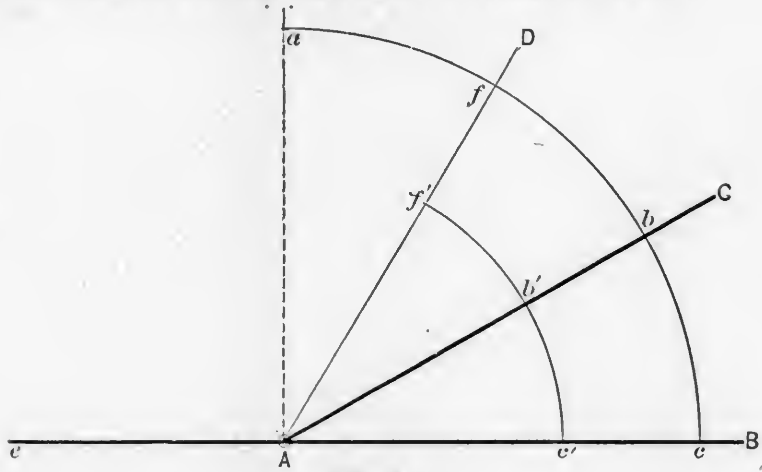


Fig. 40.

deduct 90 from the proposed number of degrees, and from the vertex *A* with the radius of a protractor draw an arc *a f*, and from the perpendicular *a A* lay off on the arc *a f* the difference between the number of degrees of the proposed angle and 90°, and draw *A D* through the vertex *A* and *f*; *e A D* will then be the required angle.

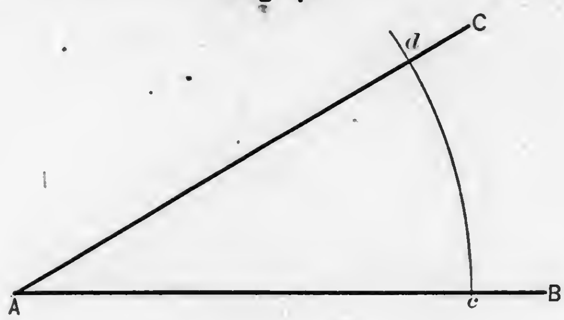
PROBLEM 11 (fig. 43). *To construct on a given line, D E, an angle equal to another angle, B A C, fig. 42.*

Fig. 41.

First Method.—Measure the angle *B A C* and then lay off another equal to it, as described in Problem 10.

Second Method.—From the vertex *A*, fig. 42, with any radius *A c* describe an arc *c d* intersecting *A B* and *A C*. With the same radius, and from *D*, fig. 43, the vertex of the proposed angle, draw an arc *g h*. Then, with a pair of compasses, take from fig. 42 the distance *c d* as a radius, and from *g*, fig. 43, as

Fig. 42.



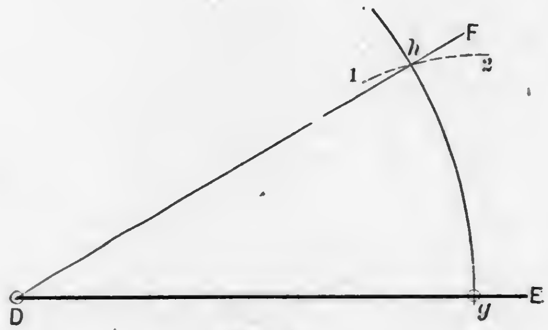


Fig. 43.

a center describe an arc 1 2 intersecting *h g* at *h*. Then draw *D F* through *h*, and the angle *F D E* will be equal to *B A C*.

PROBLEM 12 (fig. 44). *To bisect* or divide a given angle, B A C, into two equal parts.*

First Method.—From the vertex *A* of the angle with any radius draw an arc *D E*, cutting the lines *B A* and *C A* at *E* and *D*. From *D* and *E*, as centers, with any radius, draw arcs 1 1 and 2 2 intersecting each other at *F*. Through *A* and *F* draw the line *A F*, which will bisect the angle *B A C*.

Second Method.—With a pair of dividers subdivide the arc *D E* into two equal parts, and through *G*, the point of division, and the vertex *A* draw the line *A G*, and it will divide the angle *C A B* into the angles *C A G* and *G A B*, which will be equal.

PROBLEM 13 (fig. 45). *To bisect the angle between two straight lines, A B and C D, the vertex of which is inaccessible.*

If *A B* and *C D* be the two lines, draw two lines *f E* and *g E* parallel to *A B* and *C D*, so that the distance *a b* and *a' b'* between the parallel lines will be equal, and that *f E* and *g E* will intersect at *E*. By the preceding problem bisect the angle *f E g* by the line *h E*, which will also bisect the angle between the lines *A B* and *C D*.

PROBLEM 14 (fig. 46). *To trisect*† *a right angle.*

First Method.—If *D A E* is a right angle it may be divided into three equal parts by drawing an arc, *D F G E*, from the vertex *A* as a center with any radius, and then dividing this arc with a pair of dividers into three equal parts, and drawing lines *A F* and *A G* through the points of division. The angles *D A F*, *F A G*, and *G A E* will then all be equal.

Second Method.—Draw the arc *D F G E* as before. Then with the same radius, and from *E* as a center, draw the arc 1 1 intersecting *D F G E* at *F*, and from *D* as a center draw 2 2. Through the points of intersection *F* and *G* draw lines *A F* and

* To *bisect* means to divide into two equal parts.
† To *trisect* means to divide into three equal parts.

A G, and they will divide the angle *D A E* into three equal parts.

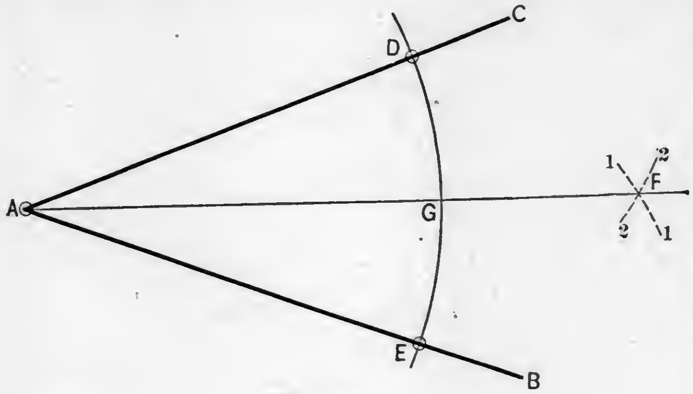


Fig. 44.

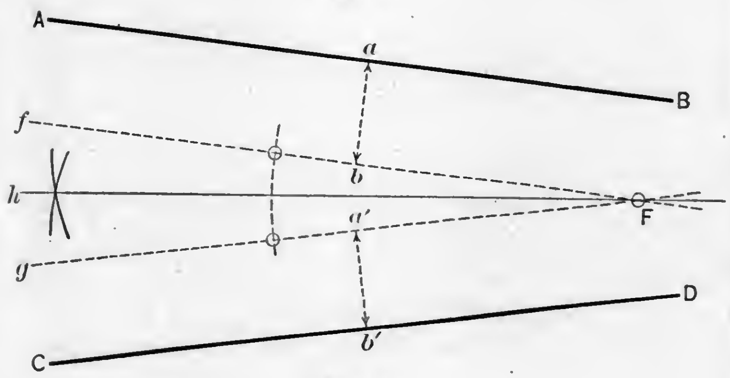
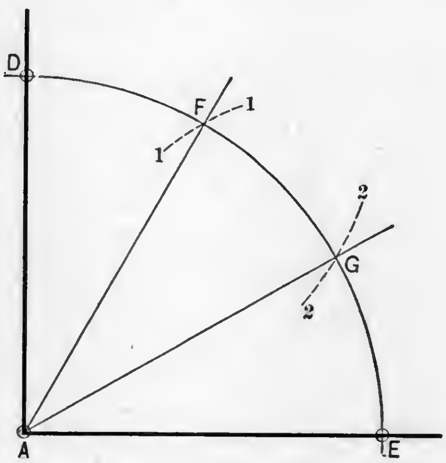


Fig. 45.

Fig. 46.



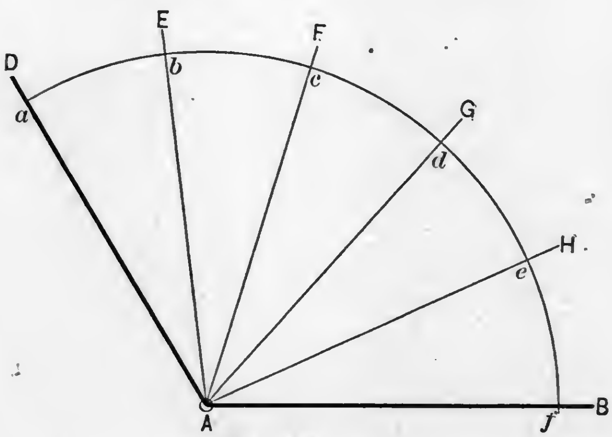


Fig. 46a.

PROBLEM 15 (fig. 46 *a*). *To divide any angle into any number of equal parts.*

Let *D A B*, fig. 46 *a*, be an angle to be divided into, say, five equal parts. From the vertex *A*, as a center, and with any radius draw an arc *a b c d e f*. With a pair of dividers, by repeated trial, divide this arc into the required number of equal parts—in this case five—and through the points of division, *b c d e*, draw the lines *A E*, *A F*, *A G* and *A H*. These lines will then enclose equal angles.

TRIANGLES.*

PROBLEM 16 (fig. 50). *Having the length of the three sides to construct a triangle.*

Let the length of these sides be 2¾", 4" and 5½". Lay down one of these sides, *A B*, fig. 50, preferably the longest. Then, with the compasses, take the length of one of the other sides, and from *B*, the extremity of *A B*, describe an arc 1 1, and with the length of the third side and *A* as a center draw another

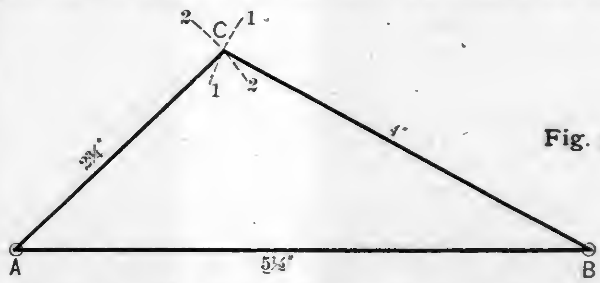


Fig. 50.

arc 2 2, intersecting the first one at *C*. Draw lines *A C* and *B C* through *A* and *C* and *B* and *C*, which will complete the triangle.

PROBLEM 17 (fig. 51). *Having the length of two sides and the included† angle of a triangle, to construct the triangle.*

Supposing that the one side is 5 in. and the other 3 in. long, and the angle between them is 35°. Draw *A B*, fig. 51, equal to 5 in. Then, with a protractor, from *A* lay off an angle $D A B = 35°$, and draw *A D* of indefinite length. From *A*

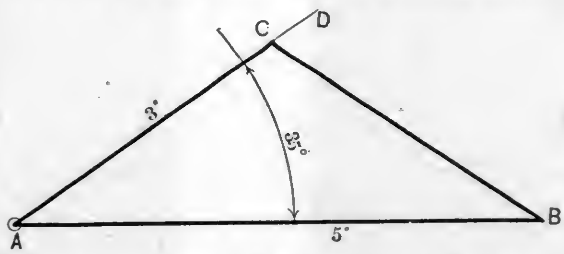


Fig. 51.

make $A C = 3$ in., and draw *C B*, which will complete the triangle.

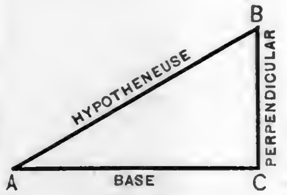
PROBLEM 18 (fig. 52). *Having two angles of a triangle, to ascertain the third angle.*

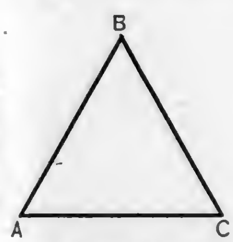
First Method.—If the two angles are given in degrees, add them together and deduct the sum from 180°; the remainder will be the third angle.

* A plane triangle (the only kind which will be considered here) is a figure bounded or enclosed by three straight lines, and which has three angles, as *A B C*, figs 47, 48 and 49. If one of the angles. *A C B*, fig. 47, is a right angle, the figure is called a *right-angled triangle*. The longest side, *A B*, which is opposite the right angle, is called the *hypotheneuse;* the lower side, *A C*, the *base;* and the other side, *B C*, the *perpendicular*.

If all the sides of a triangle are of equal length, as in fig. 48, it is called an *equilateral triangle*.

Two triangles or other figures are said to be *similar* to each other when they are of the same shape and have the same proportions, as shown by figs. 48 and 49, which represent similar triangles.





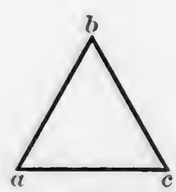


Fig. 47. Fig. 48. Fig. 49.

By the *area* of a figure we mean the amount of surface included within its outside lines. Thus a field is said to contain so many acres, or it has an *area* of so many acres, or a board has so many square feet of *area*.

Triangles and other figures are said to be *equal* when they have the same area—that is, when they contain precisely the same *space*. A figure may be *equal* to another without being similar in shape; thus a triangle and a square may have the same area and therefore be *equal*, although they are not of the same shape.

If the angles of any triangle are added together their sum will always be equal to two right angles.

† By the *included* angle is meant the angle contained between the two sides.

Second Method.—If from a line $A\ B$, fig. 52, a perpendicular $C\ D$ is drawn, then the two angles $C\ D\ B$ and $C\ D\ A$ will both be right angles, and therefore equal to the sum of the angles of a triangle. If the angles which are given are 40° and 80°, lay off from D as a vertex an angle $B\ D\ E = 40°$ and $E\ D\ F = 80°$; then $F\ D\ A$ will = the third angle of the triangle.

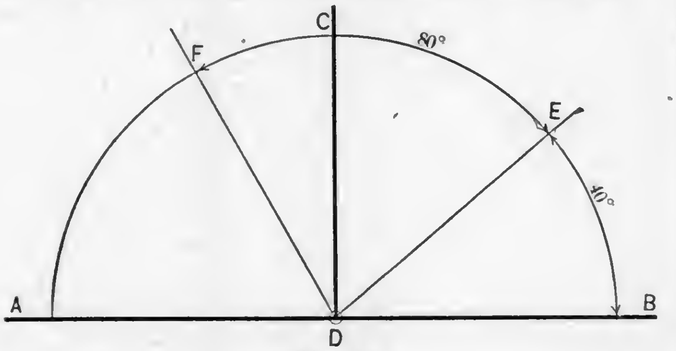


Fig. 52.

PROBLEM 19 (fig. 53). *Having one side and two angles of a triangle, to construct the triangle.*

Let $A\ B$ be the side 6 in. long. The two angles may both be adjacent to $A\ B$, as $C\ A\ B$ and $C\ B\ A$, or one of them may be adjacent and the other, $A\ C\ B$, may be opposite to the side which is given. In the latter case ascertain the third angle by the preceding problem. We will then have two angles and their included side.

Draw a straight line, $A\ B$, fig. 53, equal to the length of the given side = 6 in. From the extremities A and B lay off the angles $D\ A\ B$ and $E\ B\ A$ adjacent to $A\ B$, and extend $A\ D$ and $B\ E$ until they intersect at C; then $A\ C\ B$ will be the triangle required.

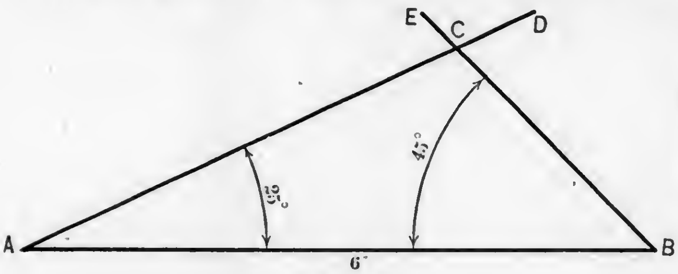


Fig. 53.

PROBLEM 20 (fig. 54). *Having the length of two sides of a triangle, and an angle opposite to one of them, to construct the triangle.*

Supposing that the lengths of the two sides are 4½" and 3½" respectively, and that the angle opposite the shorter side is 30°. Draw an indefinite line $A\ B$, and from its extremity A, as a vertex, lay off an angle $B\ A\ C = 30°$, the given angle, and extend $A\ C$. From A lay off a distance $A\ B$ = to the longer side, or 4½". From B as a center, with the length of the shorter side as a radius, describe an arc 1 1 to intersect $A\ C$, and draw $B\ C$; then will $A\ B\ C$ be the required triangle.

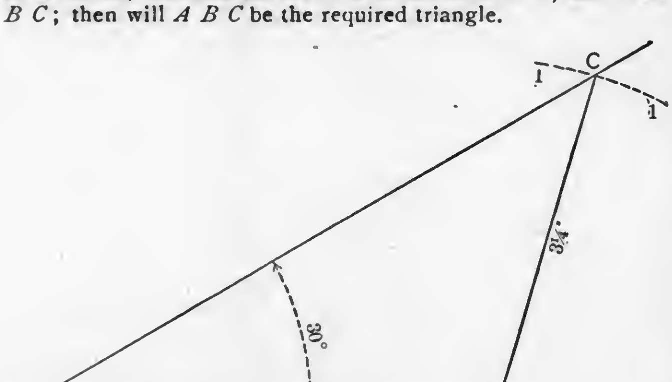


Fig. 54.

PROBLEM 21 (fig. 55). *To construct an equilateral triangle, the vertical height being given.*

First Method.—Let $A\ B$ be the vertical height. Through A and B draw the indefinite lines $C\ D$ and $G\ H$ perpendicular to $A\ B$. From A as a center with any radius draw the semicircle $a\ b\ c\ d$, and from a and d as centers and the same radius describe arcs 1 1 and 2 2 intersecting $a\ b\ c\ d$ at b and c. From A draw lines $A\ E$ and $A\ F$, through b and c and intersecting $G\ H$ at E and F. Then $A\ E\ F$ will be the required triangle.

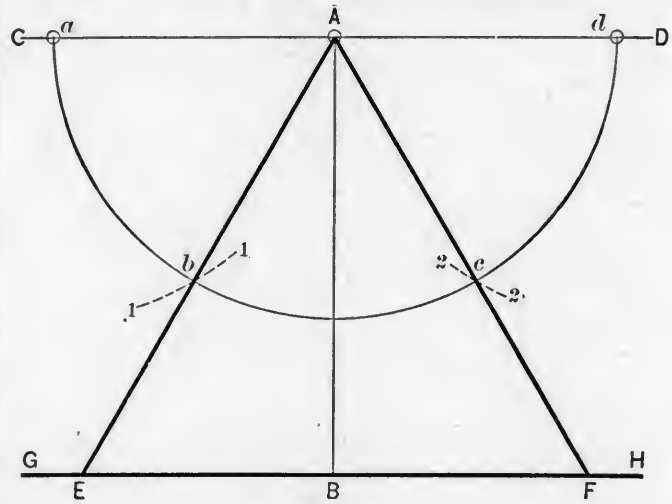


Fig. 55.

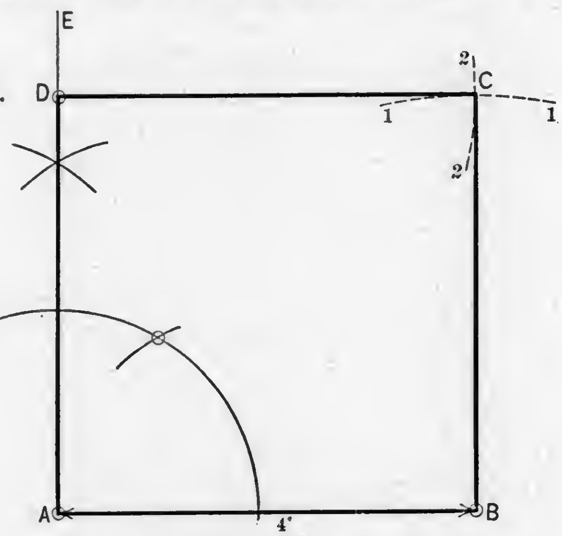
Second Method.—In an equilateral triangle the angles are all equal, and consequently each of them is 60°. $E\ A\ B$ and $F\ A\ B$ are each equal to one-half of $B\ A\ F$, or 30°. The lines $A\ E$ and $A\ F$ may therefore be most conveniently drawn through A with a 30° triangle without laying off the circle $a\ b\ c\ d$.

SQUARES AND OTHER POLYGONS.*

PROBLEM 22 (fig. 64). *Having the length of a side of a square, to construct the square.*

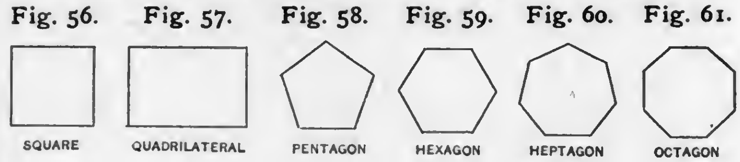
First Method.—Let $A\ B$ be the side of a square = 4 in.

Fig. 64.



* A *polygon* is a plane figure bounded by straight lines. A *triangle* is a polygon of three sides; one with four sides, figs. 56 and 57, is called a *quadrilateral*; one of five sides, fig. 58, a *pentagon*; one of six sides, fig. 59, a *hexagon*; one of seven sides, fig. 60, a *heptagon*; one of eight sides, fig. 61,

Fig. 56. Fig. 57. Fig. 58. Fig. 59. Fig. 60. Fig. 61.



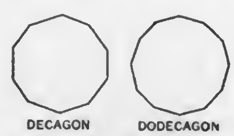


Fig. 62. Fig. 63.

an *octagon*; one of 10 sides, fig. 62, a *decagon*; one of 12 sides, fig. 63, a *dodecagon*.

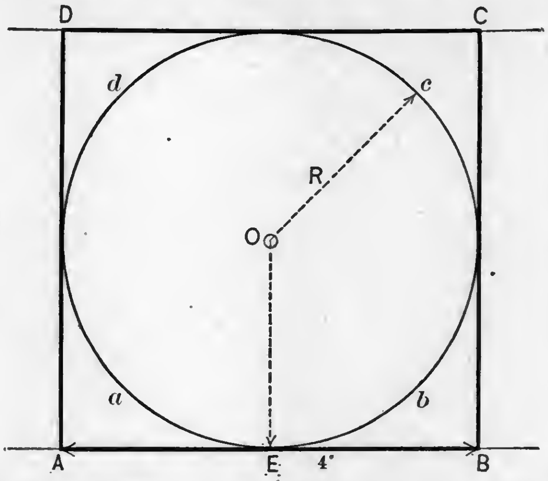
A *square*, fig. 56, is a four-sided quadrilateral whose sides are all equal, and its angles are all right angles.

A *rectangle*, fig. 51, is a four-sided figure whose angles are all right angles.

From one extremity, A, of $A\ B$, erect a perpendicular $A\ E$ to $A\ B$, by the sixth or seventh methods described in Problem 8. From A lay off on $A\ E$ a distance $A\ D = A\ B$. From B and D as centers, and $A\ B$ as a radius, describe arcs 1 1 and 2 2, intersecting each other at C. Then draw $D\ C$ and $B\ C$, and $A\ B\ C\ D$ will be the required square.

Second Method.—With R, fig. 65, = one-half the length of the side of the square, as a radius, and O as a center, describe a circle $a\ b\ c\ d$, fig. 65. Draw two parallel lines, $A\ B$ and $D\ C$,

Fig. 65.



tangent to the circle and of indefinite length. Then, with a triangle, draw $A\ D$ and $B\ C$ perpendicular to $A\ B$ and $D\ C$ and tangent to the circle. The lines $A\ B$, $B\ C$, $C\ D$, and $B\ E$ will then enclose the required square.

PROBLEM 23 (fig. 66). *Having the diagonal* $A\ C$ of a square, to draw the square.*

Bisect $A\ C$ at O. Erect a perpendicular to $A\ C$ which will pass through O. Then with $O\ A$ = one-half of $A\ C$ as a radius, and O as a center, describe arcs 1 1, 2 2, 3 3 and 4 4, intersect-

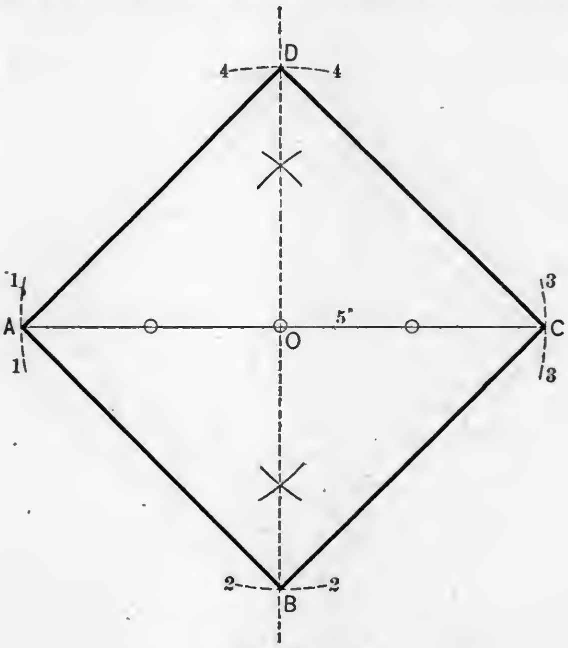


Fig. 66.

ing $A\ C$ and $B\ D$ at $A\ B\ C$ and D. Connect these points of intersection by the lines $A\ B$, $B\ C$, $C\ D$ and $D\ A$, and they will enclose $A\ B\ C\ D$, the required square.

PROBLEM 24 (fig. 67). *To construct a rectangle whose sides are of a given length.*

Supposing the sides to be respectively 5" and 3" long. Draw the line $A\ B$, fig. 67, = 5". From A erect a perpendicular $A\ E$ of indefinite length, and lay off on it a distance $A\ D$ = 3". Then with D as a center and a radius = $A\ B$ = 5" describe an arc 2 2, and with B as a center and a radius = $A\ D$ = 3" describe the arc 1 1 intersecting 2 2 at C. Draw $B\ C$ and $C\ D$, and $A\ B\ D\ C$ will be the required rectangle.

* A *diagonal* is a straight line from one angle to another, not adjacent, of a figure of four or more sides, and dividing it into two parts. $A\ C$, fig. 66, is the diagonal of the square $A\ B\ C\ D$.

PROBLEM 25 (fig. 68). *To construct a parallelogram* whose angles are not right angles, of which the sides and one of the angles are given.*

Let two of the opposite sides = $A\ B$, fig. 68, = $4\frac{1}{2}$" and the other two sides = 3", and two of the angles = 55°. Draw $A\ B$ = $4\frac{1}{2}$". From A, by the method described in Problem 11, lay off an angle $D\ A\ B$ = 55°, and draw $A\ E$ of indefinite length.

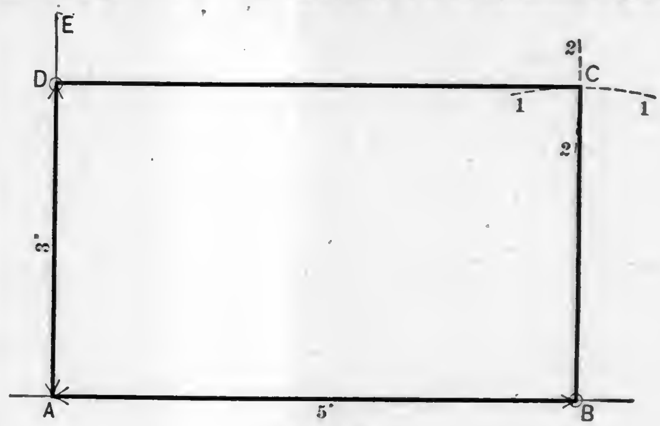


Fig. 67.

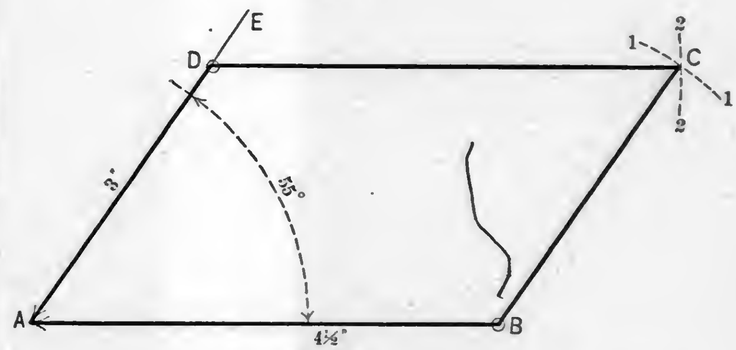


Fig. 68.

Then lay off from A a distance $A\ D$ = 3". From D as a center, and a radius = $A\ B$ = $4\frac{1}{2}$", draw the arc 2 2, and from B as a center and a radius = $A\ D$ = 3" draw the arc 1 1, intersecting 2 2 at C. Draw $B\ C$ and $D\ C$, and then $A\ B\ C\ D$ will be the required parallelogram.

PROBLEM 26 (fig. 69). *To construct a parallelogram whose angles are not right angles, of which the diagonal and its sides are given.*

If the sides are respectively $4\frac{1}{2}$" and 3" long and the diagonal $6\frac{11}{16}$", lay off one of the sides $A\ B$ = $4\frac{1}{2}$". With A as a center and the length of the diagonal draw an arc 1 1. With B as a center and a radius = the length of the shorter sides draw

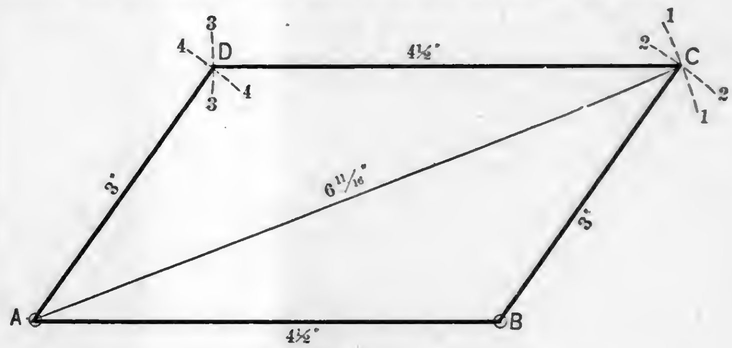


Fig. 69.

2 2, intersecting 1 1 at C. From C as a center with the length of the long side as a radius describe the arc 3 3, and from A as a center with the length of the shorter side = 3" as a radius describe the arc 4 4, intersecting 3 3 at D. Draw the lines $B\ C$, $C\ D$, $D\ A$, and $A\ C$; $A\ B\ C\ D$ will then be the required parallelogram and $A\ C$ the diagonal.

PROBLEM 27 (fig. 70). *To draw a four-sided figure, none of whose sides are parallel, the length of its sides and one of the angles being given.*

* A *parallelogram* is a four-sided figure whose opposite sides are parallel. $A\ B\ C\ D$, fig. 68, is a *parallelogram.*

If the sides are $5\frac{1}{2}$", $2\frac{1}{4}$", $3\frac{1}{2}$", and 3" long, and the angle contained between the first and second sides is 70°; then draw $A\ B = 5\frac{1}{2}$". From A lay off an angle $B\ A\ D = 70°$ and draw $A\ E$ of indefinite length. Make $A\ D = 2\frac{1}{4}$", and from D as a center

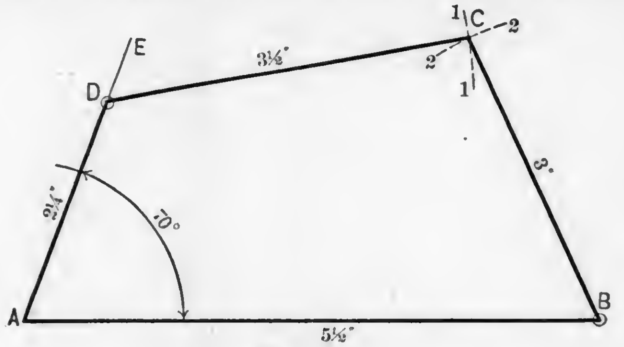


Fig. 70.

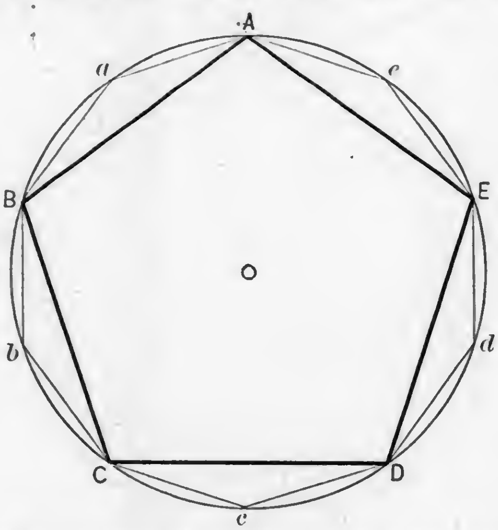
with a radius = the third side = $3\frac{1}{2}$" draw an arc 1 1, and from B with an arc = the fourth side = 3" describe an arc 2 2, cutting 1 1 at C. Then draw $B\ C$ and $D\ C$, and $A\ B\ D\ C$ will be the required figure.

PROBLEM 28 (fig. 71). *To inscribe* a regular† pentagon or other regular figure inside of a circle.*

If $A\ B\ C\ D\ E$, fig. 71, represents the circle, divide its circumference into five equal parts or as many parts as the figure has sides. Then unite the adjacent points of division, $A\ B\ C\ D\ E$, by lines $A\ B$, $B\ C$, $C\ D$, $D\ E$, and $E\ A$. Then $A\ B\ C\ D\ E$ will be the required figure.

If it was required to inscribe a decagon in the circle, its cir-

Fig. 71.



cumference should then be divided into 10 equal divisions, A, a, B, b, etc., and lines $A\ a$, $a\ B$, $B\ b$, etc., would be drawn, and they would enclose the required figure.

PROBLEM 29 (fig. 72). *To circumscribe‡ a circle with a pentagon or any other regular figure.*

If the light line in fig. 72 represents the circle, divide it into five equal parts and connect the adjacent division by lines $a\ b$, $b\ c$, etc., as in fig. 71. Then draw other lines, $A\ B$, $B\ C$, etc., parallel to these and tangent to the circle. The lines tangent to the circle will enclose a pentagon $A\ B\ C\ D\ E$ which will be circumscribed on the circle. The same method would be used for figures of more or less than five sides.

The most convenient way to circumscribe a circle with a hexagon, as shown in fig. 73, is to draw the upper and lower sides with the T square, and the other sides with a 30° triangle. $B\ C$ and $F\ E$ can be drawn with the triangle in the position shown at A, in fig. 21, and $B\ A$ and $D\ E$ with it in the position shown by the dotted lines D in the same figure. If two of the sides of the hexagon are vertical, they may be drawn by the edge $b\ c$ of the triangle in the position shown at B, fig. 21, and two of the other sides along the edge $b\ e$. The remaining sides of the hexagon can then be drawn by reversing the triangle. This way of drawing hexagons has a frequent practical application in representing six-sided nuts.

* To *inscribe* means to draw within. Thus in fig. 71 the pentagon $A\ B\ C\ D\ E$ is *inscribed* within the dotted circle outside of it.

† A *regular* pentagon or regular figure is one whose sides are of equal length.

‡ To *circumscribe* means to draw around.

Octagons, fig. 74, may also be drawn in a similar way by using the T-square and 45° triangle, as shown at C, fig. 21; the edge

Fig. 72.

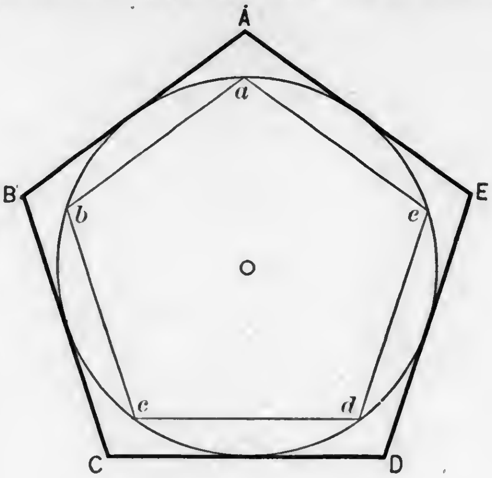


Fig. 73.

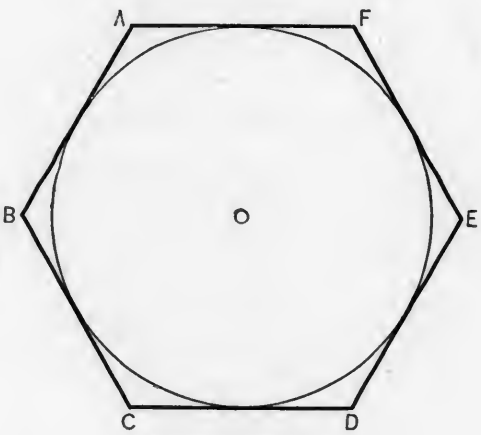


Fig. 74.

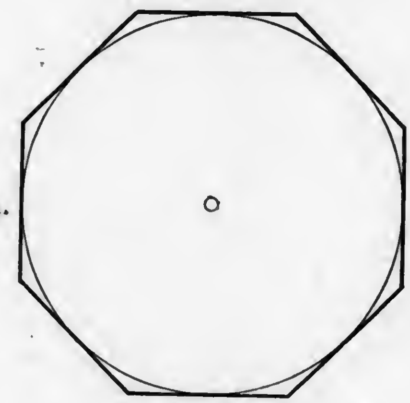
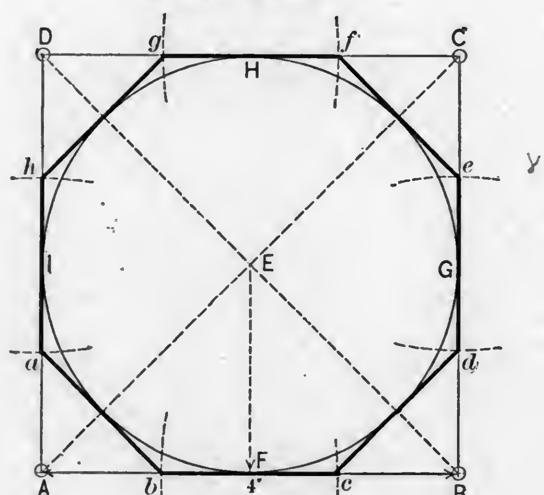


Fig. 75.



$a\ b$ serving to draw the perpendicular and $a\ c$ for the diagonal sides.

PROBLEM 30 (fig. 75). *To inscribe a regular octagon in a given square.*

First Method.—If $A\ B\ C\ D$ is the given square, draw the diagonals $A\ C$ and $B\ D$ intersecting one another at E. From E as a center and with a radius $E\ F$, draw a circle $F\ G\ H\ I$ inside of $A\ B\ C\ D$ and touching the four sides of the square. Then with a 45° triangle draw the sides $a\ b$, $c\ d$, $e\ f$, and $g\ h$ tangent to the circle $F\ G\ H\ I$; $a\ b\ c\ d\ e\ f\ g\ h$ will be the completed octagon.

Second Method.—Draw the diagonals $A\ C$ and $B\ D$ as before. Then with a radius $= B\ E$, and each of the corners A, B, C and D of the square as centers describe arcs $a\ b$, $c\ d$, $e\ f$, and $g\ h$, intersecting the sides of the square. Join the points of intersection by lines $a\ b$, $c\ d$, etc., and $a\ b\ c\ d\ e\ f\ g\ h$ will be the octagon.

(TO BE CONTINUED.)

The Merchants' Bridge at St. Louis.

THIS new bridge over the Mississippi, at St. Louis, just completed, consists of three main spans, respectively, 521.5, 523.5 and 521.5 ft., six approach spans of 125 ft. each, four braced piers of 25 ft. each and two pier spaces of 3 ft. each, making the total length 2,422.5 ft. The clearance above the St. Louis directrix is 54 ft. 3 in.

The contract for the main bridge and 425 ft. of the steel approaches on each end was let to the Union Bridge Company of New York.

The contract for the double-track elevated structure of the Terminal Railroad, on the St. Louis side, has been let to the Phœnix Bridge Company. The terminal tracks have been laid from the Water Works to Biddle Street, and it is expected that the elevated structure will be completed and all tracks laid and connections made with the St. Louis & San Francisco Railroad and the Union Depot tracks by May 1.

The general plan of the bridge and its approaches and most of the details that were recommended by the engineers, Messrs. George S. Morison and E. L. Corthell, have been followed in the actual construction of the work. Examinations made of the rock during the building of the piers, when all material overlying it had been removed, showed that in every case the piers rested on firm hard limestone rock. The rock, in every case, was leveled off, or stepped, for the iron cutting edge, and thoroughly cleaned of all loose shale, clay, sand, etc., and at least two holes were drilled five feet into it, to determine its character. The caissons were then solidly packed with concrete.

Limestone from Bedford, Ind., was used to within 3 ft. of the low water-line; above this level to the high water-line Missouri granite was used, and above this again Bedford limestone. The dimension stone was laid in Portland cement mortar, and the backing in Louisville cement.

In order to make a less abrupt break in the grade between the level grade of the bridge and that of the approaches, the two river piers were raised so that the clear height in the center of the central span is 52 ft. above high water instead of 50 ft., as required by the act of Congress, and the height at the end of the shore spans is about 4 in. below this height. This gives a much better bridge for navigation than the law contemplated.

On the west end of the bridge the approach crosses Ferry Street twice. The crossing nearest the bridge is made by a viaduct resting on cylinder piers, the crossing furthest from the bridge is a deck-span 125 ft. long resting on masonry piers. There is one other street overhead crossing, which is made by masonry abutments and steel girders. The intermediate space between the structures are either solid earthwork or a substantial timber trestle.

On the east end of the bridge, between the 425-ft. length of permanent structure and the overhead crossing at the Chicago & Alton, Bee Line and Wabash Railroads, and east of this last-named structure to the earth embankment, the intermediate spaces are filled with a wooden trestle. The bridge at the crossing of these three railroads is made by two masonry abutments on which rest a 175-ft. span and a 40-ft. steel girder. The entire bridge and approaches is built for double track.

The style of the three spans of the main bridge is a double intersection pin-connected truss with horizontal bottom chord and a curved top chord. The entire structure is of steel, except pedestals and ornamental parts, which are of cast iron, and nuts, swivels and clevises, which are of wrought iron.

The steel was required to stand an ultimate tensile strain in the sample bar of from 63,000 to 70,000 lbs. per square inch, with an elastic limit of not less than 38,000 lbs. Finished bars, selected by the engineer, were subjected to a breaking test, the requirements being an elongation of 10 per cent. before breaking. The structures are so proportioned that under all possible conditions the material cannot be subjected to injurious strains.

¶ Connections with the various railroads are made on the St. Louis side of the river by the Terminal Railroad, and on the east side by the Venice & Carondelet Belt Railroad.

Manufactures.

Locomotives.

THE Schenectady Locomotive Works are to build 40 switching engines for the New York Central & Hudson River Railroad. They have also received an order from the East Tennessee, Virginia & Georgia Railroad, which includes two compound locomotives, one for freight and one for passenger service.

AT their works in Pittsburgh, H. K. Porter & Company have lately built two very small locomotives for manufacturing establishments they are of 2 ft. gauge, with cylinders 6 × 12 in. and our driving-wheels 23 in. in diameter.

THE Manchester Locomotive Works, Manchester, N. H., are building 20 locomotives of different classes for the Boston & Maine Railroad.

AMONG other orders the Baldwin Locomotive Works, Philadelphia, have received one for seven ten-wheel engines with 20 × 24-in. cylinders for the New York, Pennsylvania & Ohio Railroad, and eight shifting engines for the Merchants' Bridge, St. Louis.

THE Pittsburgh Locomotive Works have recently completed five engines for the Vandalia Line, and are building a number for the Baltimore & Ohio Railroad.

THE Richmond Locomotive & Machine Works, Richmond, Va., have recently been enlarged by the addition of a boiler shop 185 × 92 ft. in size, and a machine shop 100 × 106 ft., containing a number of new tools. Work on hand includes locomotives for the Atlantic & Danville, the Richmond & Danville and the Chesapeake & Ohio.

THE Brooks Locomotive Works, Dunkirk, N. Y., are now very busy and are turning out four or five engines a week. Among recent deliveries are five passenger engines with 18 × 24-in. cylinders and two six-wheel switching engines with 18 × 24-in. cylinders for the Baltimore & Ohio Southwestern; 10 passenger engines with 18 × 24-in. cylinders for the Chicago & Grand Trunk; 10 mogul freight engines, with 18 × 24-in. cylinders, for the New York, Chicago & St. Louis. Orders now on hand include 10 heavy 10-wheel passenger engines, with 18½ × 24-in. cylinders, for the Cleveland, Cincinnati, Chicago & St. Louis; 10 passenger engines of the 10-wheel type, with 18 × 24-in. cylinders, for the Wisconsin Central; 25 freight engines of the 10-wheel pattern, with 17 × 24-in. cylinders, for the Lake Shore & Michigan Southern; 25 mogul freight engines, with 19 × 26-in. cylinders, for the New York Central & Hudson River, and 15 six-wheel switching engines, with 18 × 24-in. cylinders, for the Illinois Central Railroad.

THE Baldwin Locomotive Works has delivered the first of an order of 40 locomotives to the Central Railroad of Georgia. Of these six will be passenger engines with 17 × 24 in. cylinders, 30 freight engines with 19 × 24 in. cylinders and four six-wheel shifting engines with 18 × 22 in. cylinders.

Cars.

THE Denver & Rio Grande Company has fitted up its passenger cars with the new Scarritt seat, furnished by the Scarritt Works in St. Louis.

THE Van Dorston Cushioned Car Coupling Company has equipped a number of new cars for the Philadelphia & Reading Railroad with the Van Dorston cushioned coupler.

THE Atlanta & West Point shops, Atlanta, Ga., have recently turned out two very handsome passenger cars. The finish is complete, and their fine appearance is claimed to be largely due to the use of the Valentine varnishes.

THE Scarritt Furniture Company, St. Louis, has recently added a new five-story building to its works, making them probably the largest car-seat factory in operation. A number of Scarritt reclining chairs have recently been ordered by the Kansas City, Fort Scott & Memphis Railroad.

THE Lake Shore & Michigan Southern has received nearly all the 3,300 freight cars, the contracts for which were placed at

intervals last fall. The new equipment consists of 1,000 drop-bottom gondola, 1,500 box, 250 hay, and 500 platform cars. The orders for these cars were placed as follows: Wells & French Company, 1,200; Peninsular Car Company, 1,000; Buffalo Car Manufacturing Company, 100; Indianapolis Car Manufacturing Company, 200; Lafayette Car Works, 400; Barney & Smith Manufacturing Company, 400. In addition to the freight cars the Barney & Smith Manufacturing Company is finishing an order of 10 passenger, 1 dining and 5 baggage cars for the road.

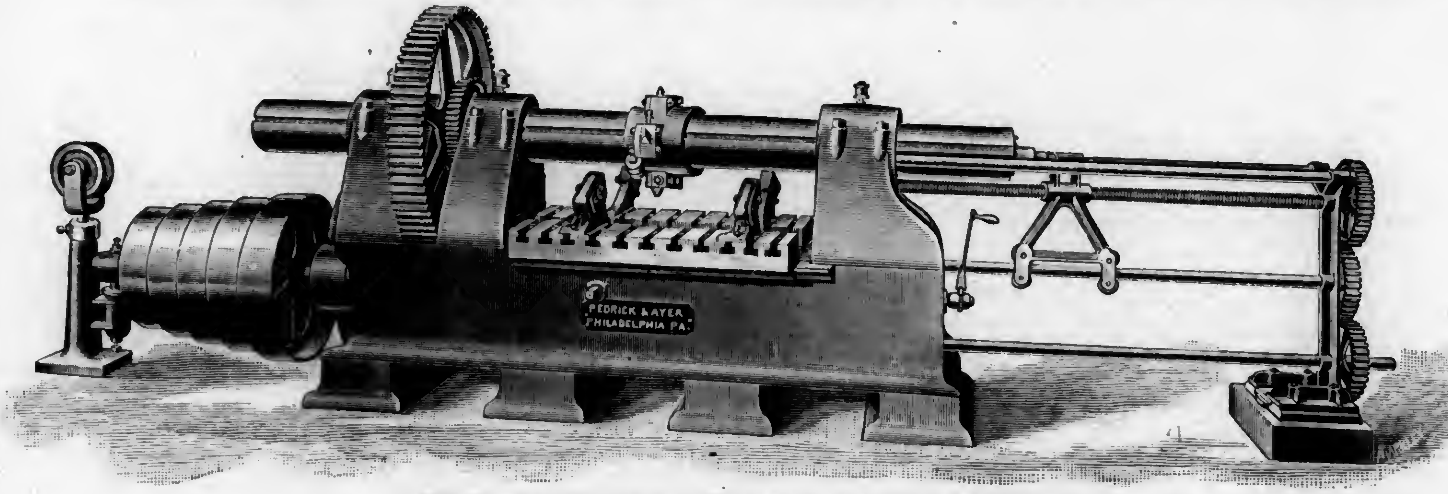
Leed's Cylinder-Boring and Facing Machine.

THE accompanying illustration shows a machine intended to bore and face locomotive cylinders rapidly and accurately. The bed, housings, and platen are very heavy, and an 8-in. bar is used driven by powerful gears $4\frac{1}{2}$ in. and 5-in. face, back-geared 36 to 1 and driven by a 5-in. belt on cones, the largest of which is 30 in. in diameter and the smallest 18 in. in diameter, with five changes. The feed is made changeable by playing change gears similar to lathes for cutting screws. The distance between the bearings for bar to revolve in is 4 ft. 6 in., but can be made to meet any requirements.

The table or platen is 36 in. long, with suitable T-slots for securing the work. From top of platen to center of bar is $17\frac{1}{2}$ in. At the end of the machine, forming a part of the cone-shaft support, is a sheave to take the weight of the bar when it is drawn out to place the cylinder on the platen. The table or platen has a sufficient amount of adjustment and is operated by a screw $2\frac{1}{4}$ in. in diameter, by a crank from either front or rear end of the machine. When desired four adjustable saddles to receive the cylinders, which have movable parts operated by screws and wrench to facilitate placing cylinders in position for boring, are furnished. When once set the machine is all right for other cylinders of same size.

At the Louisville shops of the Louisville & Nashville Railroad, this machine has been in practical operation for some time, boring 20-in. cylinders, $33\frac{1}{4}$ in. long, counter-bore $2\frac{3}{8}$ in. long, finishing them complete, with flanges faced and turned, in less than seven hours each; this is very rapid work when the composition of the metal for cylinders is considered. They are made of 2,600 lbs. of old car-wheels, chill and all, tempered with 800 lbs. of No. 1 charcoal iron, making a very hard, close mixture; with the ordinary iron that is often used, the time can be reduced very materially. They do not use facing arms, but place a side tool in the regular cutter-head and face off with that, doing satisfactory work.

This machine was designed by Mr. P. Leeds, of the Louisville & Nashville Railroad, and is made by Pedrick & Ayer, of Philadelphia.



LEED'S CYLINDER-BORING AND FACING MACHINE.

Marine Engineering.

THE New York, Lake Erie & Western Railroad Company has let a contract to Neafie & Levy, of Philadelphia, for a new ferry-boat to run between New York and Jersey City. The boat will be 230 ft. long, 38 ft. beam, 62 ft. wide over the guards, and 16 ft. depth of hold. It will be a double-screw boat with ~~a propel~~ler at each end, much on the plan of the *Bergen* of the Hoboken ferry. The engines will be of the compound type.

IN their yards at Bay City, Mich., Wheeler & Company are building a car ferry-boat for the Canadian Pacific Company, to run between Detroit and Windsor. The boat is of steel, 295 ft. long, 41 ft. beam, 17 ft. deep and will draw 11 ft. 9 in. with a deck-load of 640 tons. She is a side-wheeler, with a separate engine to each wheel, the engines having cylinders 50 in. in diameter and 114 in. stroke; the wheels are 28 ft. in diameter. There are four boilers, each 13 ft. 3 in. in diameter and 14 ft. long; the working pressure will be 85 lbs.

THE new steel steamboat *Plymouth* for the Old Colony Steamboat Company was launched at the Roach Yard at Chester, Pa., April 3. The *Plymouth* is 366 ft. over all, 350 ft. molded length, 50 ft. beam, 85 ft. over guards and 19 ft. depth of hold. She will ply between New York and Fall River, and, like the *Puritan* and *Pilgrim* of the same fleet, is constructed on the double-hull bracket plate and longitudinal system, giving her seven water-tight bulkheads and 50 water-tight compartments. Instead of a compound beam-engine like the *Pilgrim*, the *Plymouth* will have four-cylinder triple-expansion engines connected directly to the main shaft.

THE Minnesota Mining Company has been organized at Duluth Minn., with $600,000 capita lto develop a tract of iron land about four miles from Vermilion Lake and near the line of the Duluth & Iron Range Railroad. The tract includes 960 acres, and is known to be very rich in iron ore.

THE Globe Iron Works in Cleveland, O., has completed four steel steamers for the Minnesota Steamship Company; they are intended to carry iron ore from Lake Superior, and have a capacity of 2,800 tons. Each of these ships is 311 ft. long over all, 40 ft. beam and 24 ft. 6 in. deep. The engines are triple-expansion, with cylinders 24 in., 38 in. and 61 in. in diameter and 42 in. stroke. There are two boilers of the Scotch type 14 ft. diameter and 12 ft. 6 in. long, each having three furnaces. The working pressure is 160 lbs. The propeller is 14 ft. diameter and 17 ft. pitch.

Manufacturing Notes.

THE firm of Riehle Brothers in Philadelphia having been dissolved by the death of the senior partner, Mr. Henry B. Riehle, the business will be continued under the old name by Mr. Frederick A. Riehle.

IN accordance with instructions, the R. W. Hunt & Company Inspection Bureau recently inspected 10,000 car wheels made by A. Whitney & Sons for the Savannah, Florida & Western Railroad. For size each wheel was measured around the tread by a brass tape divided into spaces of $\frac{1}{8}$ in. each. The record shows that 4,325 wheels were of exactly the same circumference; 4,365 were but $\frac{1}{8}$ in. less; 881 were but $\frac{1}{8}$ in. over, while 429 were varied over $\frac{1}{8}$ in. either way. That is, the extreme variation in 8,690 of these wheels was $\frac{1}{24}$ in. in diameter, and in 881 it was only $\frac{1}{12}$ in. For roundness the wheels were tested by a true ring resting on the cone of the wheel, and none was found with a variation of more than $\frac{1}{32}$ in. at any point. For strength, 105 of the wheels were broken under the drop test by a weight of 140 lbs. falling 12 ft. The specifications required that they should stand five blows. Two wheels broke at 9 blows, while 50 required from 50 to 118 each. To start the first crack the average number of blows was 13.26; to break the wheel in two the average number of blows was 49.56. The

average depth of the chill at the root of the flange in the 105 wheels broken was $\frac{7}{16}$ in., and the depth did not vary in any case more than $\frac{1}{8}$ in. around the wheels. None of the wheels inspected were rejected because of chill-cracks, blow-holes or other imperfections, and none needed to be ground nor in any other way made smooth or true.

THE Pacific Rolling Mills, San Francisco, are adding to their works a bloomary for making steel blooms and a mill for rolling beams of large size. Heretofore there has been no mill of this kind on the Pacific Coast. The improvements will cost about $750,000 in all. The new machinery will include an engine of 1,000 H.P., which is to be built by the Risdon Iron & Locomotive Works in San Francisco.

THE works of the Simonds Rolling Machine Company at Fitchburg, Mass., are being enlarged. The company has 12 new machines of large size under construction, one of which is to be used for making steel projectiles for the Government.

Bridges.

THE Union Bridge Company has just finished a through bridge of 147 ft. 6-in span for the Clyde Viaduct in Chicago. The span has heavy, stiff lower chords with a heavy corrugated floor made of oblique Z-bars and plates. Mr. E. L. Corthell is the engineer.

THE Philadelphia & Reading Railroad has considerable heavy bridge work under way. First in importance is the Harrisburg Terminal for the new extension beyond Harrisburg. This comprises the Susquehanna River Bridge of 23 spans, 153 ft. 6 in. each, with 580 ft. of approach viaduct; the crossing over the Pennsylvania Railroad, one span of 160 ft. and a bridge across the canal of 60 ft. span. A new bridge is to be built at Port Clinton across the Schuylkill of three spans, one 200 ft., one 180 ft. and one 100 ft. There will be a bridge six miles above Port Clinton, crossing the Little Schuylkill River, of one 200-ft. span. Also a bridge of 98-ft. span at Williamsport. On opening the bids for the Susquehanna River Bridge it was found that Cofrode & Saylor, proprietors of the Philadelphia Bridge Works at Pottstown, Pa., had secured the main bridge, and the Phœnix Bridge Company the approach. The last-named company, however, threw up the contract, and it was also awarded to Cofrode & Saylor. The contracts for the other bridges mentioned were let to the Phœnix Bridge Company.

THE Pencoyd Bridge & Construction Company has the contract for the iron work for the elevation of the Pennsylvania Railroad tracks in Jersey City. Four tracks will be elevated.

THE Union Bridge Company has commenced moving the tools and machinery from the Buffalo shops to Athens, Pa. The company will vacate the old shop in Buffalo some time in June. Work on the new buildings at Athens is progressing rapidly.

THE Phœnix and the Pencoyd Iron Companies are each adding two 20-ton open hearth furnaces to their steel plants. The foundations of both are well advanced.

THE Passaic Rolling Mill Company, Paterson, N. J., has contracts for a number of small bridges for the New York, Susquehanna & Western Railroad.

THE Phœnix Bridge Company is pushing work on the St. Louis Elevated Railroad. The drawings are complete, and the work will shortly be put in the shops.

THE Hilton Bridge Company, Albany, N. Y., has contracts for two 107-ft. spans for the West Shore Railroad and one 65-ft. four-track span for the New York Central & Hudson River; also for a number of spans for the Delaware & Hudson Canal Company.

THE Trenton Iron & Steel Company has the contract for the four-track bridge for the Central Railroad of New Jersey at Point of Rocks, near Jersey City.

THE last pin in the Red Rock Cantilever Bridge was driven at 3 : 30 P.M. on Thursday, May 7, and the first train passed over at noon on May 10. The bridge was completed none too soon, for on May 9 the crossing at the Needles was washed out by a flood in the Colorado River, and traffic both ways was delayed 12 hours. Since May 10 trains have been crossing the bridge regularly.

THE Union Bridge Company has the iron work for the Memphis Bridge over the Mississippi in the shop, and work is progressing actively.

OBITUARY.

THOMAS G. NOCK, who died in Rome, N. Y., April 20, aged 61 years, was born in England, but came to this country when a child. He learned his trade in Connecticut, and in 1854 became Superintendent of the Ripley Iron & Steel Works at Windsor Locks, Conn.; in 1864 he went to Rome, N. Y., as Superintendent of the Rome Iron Works and retained that position until the New York Locomotive Works were established, when he was appointed President.

MAJOR OTHO E. MICHAELIS, Ordnance Department, U. S. A., died at Augusta, Me., April 29, aged 47 years. He graduated from the New York City College and in 1863 entered the Signal Corps of the Army, and subsequently passed the necessary examination and was appointed Lieutenant in the Ordnance Department, where he served steadily, rising gradually to the rank of Major. He was an active and efficient officer, and was thoroughly posted in his work. He was a member of several engineering societies.

JOHN VAN NORTWICK, who died in Batavia, Ill., April 15, settled in Kane County, Ill., in 1837 and took part in the first railroad building in that State, having been Chief Engineer of the Galena & Chicago Union Railroad, and later of several of the short lines which were afterward formed into the Chicago, Burlington & Quincy. He was President of the last-named Company for eight years and was also Chief of the Corps of Engineers employed to lay out canals by the State. Of late years he was largely interested in manufacturing.

T. HASKINS DU PUY, who died in Orange, N. J., May 15, aged 69 years, was born in Philadelphia and educated as a civil engineer. He began work on the Delaware & Hudson Canal and was subsequently on the Pennsylvania Railroad, where he located and built part of the mountain section of the road. He also built some of the first iron bridges in this country. Later he held important positions on the Mobile & Ohio, the Chicago & Atlantic and several other roads. For several years past he has been in retirement on account of ill health. Mr. Du Puy was considered an engineer of excellent judgment, and he was also successful as a railroad manager.

HENRY B. RIEHLE, who died in Philadelphia, April 25, was the head of the firm of Riehle Brothers, and had been for many years engaged in the manufacture of scales and testing machines. He took an active part in the business of the firm with which he was connected, devoting the greater part of his time to the improvement of the several articles manufactured by them, and superintended the manufacturing interest at the works. His loss will be greatly felt in the business community and in the several religious and benevolent associations with which he was connected. Mr. Henry B. Riehle was connected with the firm of Riehle Brothers since its organization, nearly a quarter of a century ago. He leaves a widow and one child.

DAVID BANDERALI died in Paris, March 30, aged 54 years. He was educated as an engineer at the École Polytechnique and the École des Mines, and entered the service of the Northern Railroad Company of France in 1859. He rose gradually through the various grades until he became Chief Engineer of Material and Motive Power, which position he held until his death. He visited this country several times and was well known to many American engineers, not only from these visits, but from the many courtesies which he extended to them in return when visiting France. Monsieur Banderali was a fluent writer and published many articles in the French technical papers. He also stood very high as an engineer and head of a department, and was considered one of the foremost men in his profession in France. He was a careful student of American railroad practice, and advocated the adoption of many of its features in his own country.

JAMES NASMYTH, the distinguished mechanical engineer, died at his home in Kent, England, May 7, aged 81 years. He was born in Edinburgh, Scotland, and after studying for a time at the University of that city he went to London and entered the works of Henry Maudeslay, where he remained several years. In 1834 he established himself in business in Manchester, where he gradually built up a large factory. In 1839 he matured his first important invention, the steam hammer; this is also claimed by some French engineers, but there is no doubt that Mr. Nasmyth worked out his own idea independently. The steam hammer was followed by a safety ladle for foundries, a suction fan for ventilating mines, a reversible rolling mill, and a number of devices of lesser importance. In 1857, when his

firm—then Nasmyth, Gaskell & Company, of the Bridgewater Works—had become a large concern, he retired from active business altogether, and retired to a home which he had bought in Kent. After his retirement he wrote several important scientific works, and devoted a large part of his time to the study of astronomy, in which he was deeply interested. His autobiography—edited by Samuel Smiles—was published in 1883, and is a book of great interest. He was one of the few inventors who are also successful in business, and his later years were passed in a comfortable retirement.

PERSONALS.

JOHN S. SILVER has resigned his position as Vice-President of the National Car Spring Company.

JOHN H. WINDER is appointed Superintendent of the Seaboard & Roanoke and the Roanoke & Tar River Railroads.

E. M. ROBERTS has been appointed Master Mechanic of the East Tennessee, Virginia & Georgia Railroad at Atlanta, Ga.

R. N. CAMPBELL, late on the Chicago, Milwaukee & St. Paul, has gone to Jamaica, to take charge of a railroad on that island.

G. M. BEACH, late of the Chicago & Atlantic, has been appointed General Manager of the Pittsburgh & Lake Erie Railroad.

JAMES A. NORTON has been appointed Railroad Commissioner of Ohio, succeeding W. S. CAPPELLER, whose term has expired.

EDWARD P. RIPLEY has resigned his position as General Manager of the Chicago, Burlington & Quincy Railroad, to become Second Vice-President of the Chicago, Milwaukee & St. Paul.

GEORGE L. FOWLER has opened a mechanical engineering office at 171 Broadway, New York. He will give special attention to estimates, designs, and tests of machine tools, engines, and power machinery.

MAJOR JOHN C. WINDER has been appointed General Manager of the Seaboard & Roanoke Railroad and its controlled lines. Mr. L. T. MYERS succeeds Major Winder as General Superintendent of the same lines.

GEORGE B. HARRIS has succeeded Henry B. Stone as Second Vice-President of the Chicago, Burlington & Quincy Railroad Company. Mr. Harris has been General Manager of the Chicago, Burlington & Northern Railroad.

J. T. HARAHAN has been appointed General Manager of the Louisville, New Orleans & Texas Railroad, with office in Memphis, Tenn. He has served on the Louisville & Nashville, the Lake Shore, and the Chesapeake & Ohio.

JOHN CHAMBERLAIN has been appointed Master Car-Builder of the Boston & Maine Railroad, in place of D. C. RICHARDSON, who has resigned. Mr. Chamberlain was formerly Assistant to Mr. Adams on the Boston & Albany, but for some time past has been in charge of the car works at Wichita, Kan.

JOHN W. CLOUD, Secretary of the Master Car Builders' Association, has accepted the position of General Western Manager of the Westinghouse Air Brake Company, with headquarters in Chicago, and will take up his residence in that city immediately after the annual meeting of the Master Car Builders' Association in June.

ROBERT E. PETTIT has resigned his position as General Superintendent of the Pennsylvania Railroad Division of the Pennsylvania Railroad. He has been on the road for about 20 years, serving in the engineering department until 1882; in that year he was made Superintendent of the New York Division, and was promoted to his late position in 1885.

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers.—At the regular meeting, May 7, the progress for the arrangements of the Annual Convention was announced.

A paper on the Stability of Masonry Arches, by Mr. A. S. C. Wurtele, was read by title and the subject was informally discussed by a number of the members present, Messrs. Fteley, Hardy, Owen, Shinn, Cohen, Bogart and Brush giving instances from their experience.

The tellers announced the following elections: *Members:* Holland W. Baker, St. Louis; Henry H. Carter, Boston; Henry A. Herrick, Spokane Falls, Wash.; Edward C. Jordan, Portland, Me.; Gustave Kaufman, Allegheny, Pa.; John P. Kelly, Troy, N. Y.; Albert B. Knight, Butte City, Mont.; Olin D. Leisenring, Cleveland, O.; Otto J. Marstrand, Brooklyn, N. Y.; Albert S. Riffle, Walla Walla, Wash.; Charles W. Staniford, New York.

Associate: Malverd A. Howe, Terre Haute, Ind.

Juniors: George G. Earl, Montgomery, Ala.; Charles E. Fowler, Muncie, Ind.; William J. Stewart, Rochester, N. Y.; Arthur C. Wheatley, Henry C. Yeatman, San Cristobal de las Casas, Mexico; Albert H. Zeller, St. Louis, Mo.

Boston Society of Civil Engineers.—At the regular meeting in Boston, April 16, reports were received from the Committees on National Public Works, on Weights and Measures, on the Library, and on Highway Bridges. The last-named Committee reported in favor of conservative action, but believed that reform could best be obtained by free dissemination of information and by a law for the periodical examination of the structures. As a preliminary step they advised a commission of experts to report upon the condition of existing bridges, and to prepare recommendations for the Legislature.

Professor Woodbridge gave an account of the system of heating and ventilation of the new engineering building of the Massachusetts Institute of Technology.

New England Railroad Club.—At the regular meeting in Boston, May 14, the subject was the Length of Rigid Wheelbase permissible on American Railroads. Mr. F. M. Twombly read a paper on this subject, giving some notes of experience with different types of locomotives on the road having many curves.

The subject was discussed by Messrs. Richards, Marden, Allen and others. Mr. Marden stated that he had run special cars with 10-ft. wheel-base carrying exceptionally heavy loads, and also that he had cars running with 13-ft. wheel-base, and sharp flanges were almost unknown. He was satisfied that with any curve on New England roads with an 11-ft. wheel-base and M. C. B. standard axle, there was sufficient play given to prevent any bad effects.

Engineers' Club of Philadelphia.—At the regular meeting, March 15, Mr. T. Carpenter Smith presented an account of the Method of Towing Coal Barges on Western Rivers.

Mr. Wilfred Lewis presented an account of a recent visit to the works of the Simonds Rolling Machine Company in Fitchburg, Mass.

AT the regular meeting, April 19, it was decided to lay the matter of the revision of rules for the election of members on the table. An amendment changing the dues of members was presented.

Mr. Wilfred Lewis presented a description of a new Shaft Coupling for the transmission of power to traveling cranes, etc.

Mr. Easton Devonshire read a paper on the Purification of Water by Means of Metallic Iron, calling attention to applications of this process made in England and Belgium with much success.

AT the regular meeting, May 3, it was decided to resubmit the amendment increasing the dues of the resident members.

The Secretary presented for Mr. William H. Dechant a paper on the Mountain Railroads of Reading, Pa., accompanied by a map giving the alignments of the roads, which are generally gravity lines.

The Secretary presented for Mr. J. Foster Crowell a paper on Interoceanic Canal Prospects, describing the present condition of the Panama Canal works, and also the condition of affairs in Nicaragua.

Mr. Edwin S. Crawley presented a paper on the Lobnitz System for Breaking up Rocks under Water without Explosives. The principle consists in producing a shattering of the rock by the action of a heavy mass dropped from a convenient height and acting like a projectile.

Engineers' Society of Western Pennsylvania.—At the regular meeting in Pittsburgh, February 18, Mr. A. Dempster presented the report of the delegation appointed to attend the convention held in Harrisburg, January 23, to discuss changes in the road laws of the State. It was voted to continue the Committee on Highway Roads, with instructions to report from time to time.

Mr. Dempster then read an interesting and practical paper on

the Road Problem, which was discussed by Messrs. Wilkins, Roberts, Kirk, Johnson, Becker and others.

Mr. Simon H. Stupakoff was elected a member of the Society.

AT the regular meeting in Pittsburgh, March 20, L. B. Stillwell read a paper on Distribution of Light and Power by Electricity. He stated, among other things, that the capital now invested in electric light and power companies amounted to over $275,000,000, and that there are 109 street railroads with 580 miles of track now operated by electricity.

AT the regular monthly meeting in Pittsburgh, April 15, Mr. W. C. Quincy read a paper on Reminiscences of Railroad Building on the Baltimore & Ohio. He gave extracts from the early reports of the road, and mentioned his experience in 1849, when he was a member of an engineering party having in charge the building of tunnels on the western part of the road. There was some discussion by members present.

The following were elected members of the Society: Daniel Ashworth, W. A. Giles, William Morgan, James Ritchie, Fred. A. Scheffler, and Charles F. Scott.

Civil Engineers' Club of Cleveland.—At the regular meeting, May 13, Mr. C. O. Palmer resigned his position as Secretary of the Club. A Memoir on the Life of Mr. James S. Oviatt, a late member, was read.

The Committee on Affiliation with the American Society of Civil Engineers presented a report which was accepted, and the Committee requested to attend the Conference in New York in June. Mr. Thompson presented the Club with a carved stone containing the name of the late Charles Latimer.

Mr. G. A. Hyde read a paper on Gas-holder Tanks, in which the difficulties of founding large tanks on a hill-side composed of alternate layers of clay and quicksand were shown. This was followed by a general discussion, which turned principally on the nature of the soils about Cleveland.

Engineers' Club of Cincinnati.—At the regular April meeting of the Club one new member was elected and four applications for membership were received.

Professor T. H. Norton, of the University of Cincinnati, delivered a very interesting lecture on Aluminium, the metal which is at present receiving so much attention from metallurgists and engineers, and which is destined to be the metal of the future, on account of its adaptability for use for a multitude of purposes where iron and steel are now employed, the only drawback to its general use at present being the great expense attendant upon obtaining it in a commercial form. This, however, by reason of various experiments and the improvements made in the manner of manipulation, is being rapidly overcome.

AT the regular March meeting of the Club three new members were elected and one application for membership received. The date for holding the regular meeting in April was changed from the third to the fourth Thursday.

The paper prepared and read by Colonel William E. Merrill comprised an extended review of the history, extent, development, conduct, and cost of the construction and maintenance of the inland navigable water-ways of France, which include 3,000 miles of canals, 2,050 miles of canalized rivers, and 1,850 miles of rivers that are used for purposes of navigation, which are all with slight exceptions under the management of the Government.

Engineering Association of the Southwest.—At the regular meeting in Nashville, Tenn., May 8, Messrs. Kenneth McDonald, Donald McDonald and Dexter Belknap, all of Louisville, Ky., were elected members.

The Executive Committee presented a report recommending a limited form of affiliation with the American Society of Civil Engineers, the Association to retain its independence in all matters of management, election of members, etc. The report also suggested a general affiliation of all engineering societies. After discussion it was adopted, and Messrs. McLeod, Landreth and Foster were appointed a committee to attend the meeting of the American Society in June, as representatives.

Mr. George Reyer read a paper on the Duty Test of the Holly-Gaskill Engine at the Nashville Water Works. The engine is a vertical compound condensing engine, with two high-pressure cylinders 33 in. and two low-pressure cylinders 66 in. in diameter, all 60 in. stroke. The pumps are single-acting plunger pumps 27 in. in diameter placed in a dry well directly under the steam cylinders, the pump-rods being extensions of the piston-rods. The latter are also connected by overhead beams and connecting rods to cranks, set at an angle of 90°, on a shaft carrying a 24-ft. fly-wheel. The condenser is a surface condenser, and there are four air-pumps and four feed-pumps driven from the main engines. The test gave these results: Duration of test, 4 days, 8 hours and 52 minutes. Total U. S. gallons pumped, 49,776,080; average head pumped against, 268.7 ft.; actual duty of boiler and engine per hundred pounds of coal consumed, 72,223,992 ft.-lbs.; duty of engine alone per 500 lbs. of steam used, crediting engine with work done by feed-pump and with heat imparted to feed-water by condenser, 94,263,339 ft.-lbs.; revolutions during test 85,249; gallons pumped (computed by displacement), 50,711,220; relative per cent. of slip, 1.84; average capacity per 24 hours, 11,365,628 gallons; actual evaporation per pound of coal from feed at 50° F. to steam at 80 lbs. pressure, 6.35 lbs.; equivalent evaporation per pound combustible from and at 212° F., 9.31 lbs.

The paper was discussed by members present, and it was stated that the leakage of the reservoir and of the force-main (four miles in length) averaged 507,400 gallons per 24 hours, when the reservoir was filled to a depth of 31 ft. The reservoir is composed of solid rubble masonry walls, from 36 ft. to 38 ft. high, 8 ft. thick at top and 26 ft. at bottom, curved in profile, with concrete core throughout the full height.

Professor Landreth showed and explained a new binocular hand-level, making the objection that it was liable to error, as the accuracy of its work was dependent on a perfectly balanced condition of the vertical muscles moving the two eye-balls of the observer—a condition very rarely existing. Experiment had supported this objection.

Engineers' Club of St. Louis.—At the regular meeting in St. Louis, March 19, Professor J. B. Johnson read an address on the Organization of a Federal Council of Engineers, the paper being the result of his investigations as member of the Committee selected to prepare an address to the engineers of the country on this subject. He mentioned as among the functions of a general organization the establishment of uniform qualifications for admission to the different societies; proper definition of the title engineer; the formation of a joint library; joint publication of papers and representation in the control of State and municipal engineering works.

This called out a long and active discussion, in which Messrs. Sedden, Meier, Moore, McMath, Potter, Ferguson, Wheeler, Beahan and Taussig took part, considerable opposition being manifested to the proposed general organization.

AT the regular meeting, April 2, Frederick Egner, John J. Sanders and James N. Tiernan were elected members.

Mr. Thomas Long addressed the Club on the erection of some recent large bridges, showing a number of views of the new Merchants' Bridge at St. Louis, the Cairo Bridge and others.

Mr. Frank Nicholoson read a paper on the Pemberton Concentrator, in which he said that there was a widespread opinion that the concentration of ores was of doubtful value. This was followed by a discussion in which strong opinions were expressed as to their usefulness.

AT the regular meeting, April 16, the Committee on Affiliation with the American Society of Civil Engineers submitted a report which was made a special order for discussion at the next meeting.

Mr. Isaac A. Smith read a paper on Railroad Inclines, giving experience in their construction and operation, and suggesting some improvements. This paper was discussed by members present.

The Secretary read a paper by Mr. Arthur J. Frith on the Screw as an Element of Mechanism, giving considerations as to the proper design of the screw for different purposes and to its uses as a means of transmitting power. This paper was also discussed by members present.

Mr. Robert Moore exhibited some cubes of clay taken from the bottom of the Mississippi at Memphis. Professor Johnson gave the Club some data regarding recent Tests of Granitoid Beams, which showed that a mixture of six parts of granite to one of Portland cement was stronger than mixtures having larger portions of cement. This statement was very fully discussed.

AT the regular meeting, May 7, Professor Arthur T. Woods read a paper on Compound Locomotives, with illustrations. Mr. Otto Schmitz read a paper on Granitoid Curb and Gutter, giving particulars of the composition of the artificial stone known by that name. Both papers were discussed by members present.

The special order was then taken up, being the report of the

Committee on Affiliation with the American Society of Civil Engineers. This report was very full, and proposed as the outline of a plan to confer upon any association of engineers, one-fifth of whose members are connected with the American Society, the privilege of becoming a branch or chapter of that Society, in a restricted sense, the constitution to be in harmony with that of the general society. Such associations are to be independent of each other, and to be represented in the American Society only by such of their number as are members of that Society; they were to be also self-governing as to all local circumstances. Professional papers submitted to the branches are to be published by the American Society, the local club to make contribution to the cost of publication at rates to be fixed. Provision should be made for two general meetings of the Central Society in each year at which all business affecting general interests should be transacted.

This report was discussed at some length, and it was voted that the recommendations on the Committee be adopted as the sentiment of the Club, and that notice should be sent to all other engineering societies.

Western Society of Engineers.—At the regular meeting in Chicago, May 7, the Committee on Rapid Transit and Terminal Facilities in Chicago presented a report offering three plans for discussion: 1. A complete system of elevated roads. 2. A complete system of depressed tracks. 3. A system partly elevated and partly on the surface. A minority report was also presented recommending the third system only. Letters on the subject were read from a number of engineers and railroadmen, and estimates and plans were also presented by Mr. A. F. Robinson and Colonel Richard P. Morgan. The discussion will be continued.

Northwest Railroad Club.—At the regular meeting in St. Paul, May 10, the first subject for discussion was Driver Brakes, which was introduced by Mr. William McIntosh.

The second subject was the Master Car Builders' Rules for Interchange, with the amendments expedient. This was introduced by Mr. G. F. Ward, and was generally discussed by members present.

Engineers' Club of Minneapolis.—A new club under this name was organized in Minneapolis, Minn., May 7, taking the place of the old organization. Meetings will be held once a month, and it is hoped that the Club will be active and successful. The officers are: President, Professor W. A. Pike; Vice-President, William De La Barre; Secretary and Treasurer, F. W. Cappelen; Librarian, W. W. Redfield.

Northwestern Track & Bridge Association.—At the regular meeting in St. Paul, Minn., March 15, Mr. James Manning read a paper on the Best Method of Protecting Track from Snow. In this paper he spoke at considerable length on snow fences and their proper arrangement, recommending that they should be at least 8 ft. high, and, as a rule, should be placed 100 ft. from the track. He also spoke of the planting of trees at cuts, recommending willows for this purpose, and said that in prairie country a great deal can be done by raising the grade line slightly above the general surface. This paper was generally discussed by the members present, and Mr. Manning's recommendations as to fences were approved by vote.

The Elevation of Track on Curves and Cattle Guards and Culverts were selected as subjects for the next meeting.

AT the regular meeting in St. Paul, Minn., April 12, Mr. G. W. Downing read a paper on the Elevation of Track on Curves, which was generally discussed; as usual many differences of opinion were developed on this point.

The second subject for the evening was Cattle Guards and Culverts, which was discussed by Messrs. Stevens, Copeland, Downing, Pearson, and others.

Denver Society of Civil Engineers.—At the regular meeting in Denver, Col., April 22, it was decided to hold a convention of all the civil engineers in the State at Manitou, about the time of the opening of the rack-railroad up Pike's Peak.

Mr. C. G. Anderson read a long and interesting paper on Large Irrigation Canals, treating of their construction, maintenance, and operation very fully.

Engineers' Club of Kansas City.—On Friday evening, February 28, the Club held its Annual Dinner at the St. James Hotel, Kansas City. There were 33 present, including 22 members and invited guests. After a most satisfactory repast toasts were responded to by President W. H. Breithaupt, O. B. Gunn, F. E. Sickels, K. Allen, A. J. Mason, G. W. Pearsons and D. W. Pike, and entertaining reminiscences of engineering experience were given by Mayor Davenport, Major Gunn, Mr. E. I. Farnsworth and Mr. Henry Goldmark. Mr. William B. Knight filled the office of toast master in a most satisfactory manner.

AT the regular meeting, March 3, R. J. McCarty was chosen a member. It was resolved to hold meetings hereafter on the second Monday of each month. The Secretary presented in behalf of Mr. Thomes a large number of valuable Government Reports.

Mr. G. W. Pearsons read a paper on Photography applied to Surveying, in which he said: "The focal length of camera best adapted to this work is from 12 to 15 in. The image formed on the sensitive plate represents a series of right lines passing through the center of the lens from the landscape to it. If, therefore, the plate is in correct position it will give a mathematically correct copy, capable of direct measurement, and to a much greater degree of accuracy than would be at first imagined.

"For purposes of precision proper regard must be paid to the positions of the plate and camera. The former must be truly vertical, and, for a proper definition of the horizon, its edges should be horizontal. The angle covered by the plate must be known, and sufficient lap should be allowed to join consecutive prints.

"The centers of plates should be correctly located, vertically and horizontally, as they must be measured by a scale of tangents from the vertical center and horizon. The focal distance should remain fixed.

"After taking a series of views from the first station, proceed to the next point and take another set in the same manner, intersecting the first. The points of observation being known, these intersections determine any desired point in the field of view. The third station bears on the first two, the fourth on the second and third, etc., forming a continuous triangulation on which most points may be defined by three intersections. Any point so determined is also defined as to height by the tangent of its distance from the point of observation. The plates, therefore, give vertical as well as horizontal definitions of the field, and with a degree of accuracy which will surprise the engineer."

AT the regular meeting, May 1, Karl Wenntrock was chosen a member, and E. J. Lawless an associate.

Colonel S. N. Stewart made an address on Draw Bridges Closed by Water Power, and on Water Motors as used in Europe. Three methods of closing floating draws by the current of a river were shown: in the first the current acting directly on large wings or planks; in the second the draw is closed by a car, which is forced up an inclined road by the action of the current, and in the third it is closed by the action of the current on a boat with submerged vanes. It was also stated that motors operated by the current of a stream were used very much more in Europe than in this country.

Montana Society of Civil Engineers.—At the regular meeting in Helena, Mont., March 15, an amendment in relation to the election of candidates was proposed and submitted to ballot.

The Secretary was instructed to send printed copies of the Society's letter to Honorable T. H. Carter on the subject of Public Land Surveys to the surveyors general of the different States and Territories and to the secretaries of the different engineering societies, asking for their co-operation in securing the reforms in the present system of surveys recommended in the letter. Also to send copies to the Congressmen from the Western States.

Mr. Keerl exhibited a fine transit made by Buff & Berger, of Boston, used in the construction of the Wickes Tunnel on the Montana Central. Discussion followed on different styles of engineering instruments.

Technical Society of the Pacific Coast.—At the regular April meeting in San Francisco, a committee, consisting of Messrs. L. Wagoner, E. J. Molera, Ross E. Browne, F. Soulé, and L. M. Clement, was appointed to make investigations to determine the yielding of the Bear Valley Dam under strain, in pursuance of the suggestions made by the American Society of Civil Engineers.

Mr. Randall Hunt read a paper on Coffer Dams and Founda-

tions under Water, describing the caissons used in building the sea-wall at the foot of Market Street, San Francisco.

Mr. L. Wagoner described a singular structural change of material under strain—a lateral shrinkage of metal rods from elongation beyond the elastic limit, not uniform but intolerably well defined strata or sections transverse to the axis. He also explained how the spectrum gave colors varied by stress in cylinders of glass. Further experiments are to be made on this point by Mr. Wagoner and Commander Gilmore, U. S. N., and the results will be submitted to the Society.

Master Mechanics' Association.—The Committee on Brick Arches in Locomotive Fire-boxes has asked for information on that subject, requesting members to send their experience with such devices and also descriptions and drawings of the plans used.

Master Car-Builders' Association.—The 24th annual convention will be held at Old Point Comfort, Va., commencing Tuesday, June 10, at 10 A.M.

Headquarters will be at the Hygeia Hotel.

The revision of the Rules of Interchange is the special order of business at 10 A.M., on Wednesday, June 11.

National Convention of Railroad Commissioners.—The Committee appointed at the meeting held in March, 1889, has issued a call for a second convention, to be composed of the Interstate Commerce Commission and the Railroad Commissioners of the several States. This convention was to meet in Washington, May 28 ; the subjects suggested for consideration are : Harmony in Railroad Legislation ; Annual Reports from Carriers ; Uniformity in Railroad Accounting ; Classification of Railroad Statistics ; Classification of Freight ; Regulating Railroad Construction ; State Railroads ; Reasonable Rates, and Safety Appliances for Railroad Cars.

American Society of Mechanical Engineers.—Cincinnati was selected as the place for holding the annual convention of the Society of Mechanical Engineers this year. The first session was held in the Scottish Rite Cathedral, on Tuesday evening, May 13, at 8 P.M. The meeting was opened by Mr. George A. Gray, of Cincinnati, who introduced Mr. M. E. Ingalls, President of the Cleveland, Columbus, Cincinnati & St. Louis Railroad, who made a happy reception address, and Professor H. T. Eddy, Dean of the University of Cincinnati, also welcomed the Society with a few brief remarks. To this cordial reception Mr. Oberlin Smith, the President of the Association, responded. Owing to the illness of a member of his family Secretary F. R. Hutton could not attend the meeting. Mr. C. J. H. Woodbury therefore acted in his place.

After the welcome and the response the Society proceeded immediately to the business for which it was assembled. Abstracts of the following papers were read :

J. E. Denton : The Measure of Durability of Lubricants.

C. S. Dutton : Some Experiences with Crane Chains.

George H. Barrus : Memoranda on Indicating Engines of the Steamer *City of Richmond*.

Each paper was discussed, many of the engineers taking part. After the regular exercises a lunch was served, and the members of the Society were given the opportunity of becoming acquainted.

Wednesday was the field day of the convention, and sessions were held in the morning, afternoon, and evening. At the opening of the morning session the Secretary's report was read, and reports were read on the Duty of Pumping Engines—which was accepted ; on Standard Tests and Methods of Testing Materials—which was not final, so the Committee was continued ; on Standard Dimensions of Pipe Flanges—read and Committee continued.

Mr. Forsyth moved that a Committee of seven be appointed to report on methods of testing locomotives. The resolution was advocated by Messrs. Wall, Webber, Strong, and Barrus, and was then adopted. Subsequently the following Committee was appointed : Professor C. B. Richards, H. B. Stone, Allen Stirling, F. W. Dean, William Forsyth, James E. Denton, and Axel Vogt.

The first paper read at the morning session was one by Mr. W. F. Dixon on the Efficiency of Locomotives. It was discussed at considerable length, but nothing very new was brought out. The compound locomotive was talked about in a desultory way, but none of those who took part in the discussion had any important facts to present. So far the advantages of the compound locomotive seem to be like a Scotch verdict, "not proven." The friends of the system report an economy of from 15 to 20 per cent. in fuel consumption. Whether this will be sufficient to compensate for the increased first cost and cost of repairs still remains to be shown.

The next paper was on Working Railroads by Electricity, by Willis E. Hall, and called out an animated discussion. In a written commentary on this paper Mr. Scheffler attempted to refute some of Mr. Hall's data, and tried to prove that the expense of operating an electric railroad, if much power was required, would be so great as to be prohibitory.

Mr. Spaulding said that if the data quoted by Mr. Scheffler were correct, most of the electric railroads were now on the verge of ruin. He also called attention to the fact that electric motors had considerably more adhesion than ordinary locomotives. The reason, he thought, was not yet fully understood, but the fact had often been observed. The absence of reciprocating parts in electric motors was also an important matter, and he thought that ultimately water power would be utilized for running electric motors.

Another member said that the application of a higher degree of mechanical skill to the problem of electrical science would be very advantageous, and that the amount of quackery which has been palmed off on the public as electrical engineering would seem incredible to those who have not had opportunities to know of it.

Mr. Barker observed that there was now a disposition to return to the use of a separate motor rather than to drive from each axle.

Mr. Sweeney called attention to the fact that electric locomotives could be run and managed by a cheaper class of labor than is required to manage steam locomotives. The expense of applying an electric motor to each car is a serious difficulty in propelling them in that way.

Mr. Rogers thought that the motive power on electric railroads should be distributed over the whole train. He would also like to learn the reason for the increased adhesion of electric motors.

Mr. Webber said that it did not follow that a large trunk line railroad could be operated successfully and profitably with electricity because a street road could be worked by such means.

The discussion was of a very desultory character, and was chiefly an expression of the anticipations of those who took part in it, and to a great extent was a sort of engineering "Looking Backward."

The next paper was on the Determination of Sensitiveness of Automatic Sprinklers, by A. F. Nagle. Mr. Woodbury quoted statistics of the cost of fires with and without sprinklers, showing that when sprinklers were used the loss from fires was only about 6⅔ per cent. of what it was when they were not used. He also referred to the defects of many sprinklers which are used, and said that he has many specimens which would be no more use in preventing fires than so many Hindoo idols would be.

Papers were then read on Hirn & Dwelshauvers' Theory of the Real Steam Engine, by Professor Thurston ; Tests of Several Types of Engines under Conditions found in Actual Practice, by R. C. Carpenter ; Comparative Tests of a Hot Water and a Steam Heating Plant ; Note on Kerosene in a Steam Boiler, both by Mr. Carpenter.

At the afternoon and evening sessions the following papers were read and discussed : A Use for Inertia in Shaft Governors, by E. J. Armstrong ; A Governor for Steam Engines, by Jesse M. Smith ; Effect of an Unbalanced Eccentric in Shaft-Governed Engines, by John E. Sweet ; An Open-end Mercury Column for High Pressures ; An Automatic Absorption Dynamometer, by G. J. Alden ; Peclet's Treatment of Chimney Draft, by J. B. Webb ; the Mechanical Theory of Chimney Draft, by J. B. Webb ; Graphic Representation of Thermodynamic Quantities, by Professor De Volson Wood ; Test of a Refrigerating Plant by the same author ; A Universal Calorimeter, by George H. Barrus.

Thursday was devoted to excursions. At the invitation of the Niles Tool Works, the members of the Society took a special train in the morning and visited that establishment at Hamilton. After spending several hours in looking through these well-equipped works, they were taken to picnic grounds a few miles from Hamilton, and a bountiful lunch was served. Music, wine, and dancing gave a delightful coloring to engineering subjects. On the return of the train to Cincinnati it stopped at Ivorydale, and the members visited the soap works where the famous ivory soap is made. Each member—and his wife, if he had one with him—was presented with a cake of soap, with the assurance that if properly applied it would keep even a person's conscience clean.

In the evening a reception was given to the members by citizens of Cincinnati at the Art Museum. A local reporter described the reception as follows :

"The Art Museum, shining afar from its lofty seat, was the scene of a very brilliant social event. From 8.30 until 10 the

roll of carriages to its doors was ceaseless, while every street car was packed. At 10 o'clock, when the reception was at its height, fully 700 people were walking about through its broad corridors, admiring the treasures of art which adorn them. The Cincinnati orchestra played in the balcony overlooking the entrance hall. The gentlemen were almost all in full evening dress; the ladies in demi-toilettes, and some in full evening dress. It was an assembly of Cincinnati's best society together with the visitors.

"Something after 9 o'clock Sir A. T. Goshorn welcomed the guests of the evening, and Mr. Woodbury replied."

The last session was held on Friday, when the remaining papers were read and discussed. These were on Heating Furnaces, by D. K. Nicholson; Equilibrium Arch Curves, by H. H. Suplee; the Kinzua Viaduct, 1882, by T. C. Clarke; the Length of an Indicator Card, by J. B. Webb; Indicator Cards of the Pawtucket Pumping Engine, by D. S. Jacobus, and on the Effective Area of Propeller Screws.

NOTES AND NEWS.

A Well-Equipped School.—The workshops of the Rose Polytechnic School at Terre Haute, Ind., are, it is claimed, the most complete of any of their class in the country. In the course in Mechanical Engineering particular attention is paid to shop practice and actual construction, the students being required to work in the shops as well as in the drawing rooms and lecture rooms. Over $40,000 were expended in fitting up these shops and supplying them with tools.

Multiple Screw Propulsion.—Although the exigencies of safe marine propulsion clearly enough demonstrate the necessity for spreading the enormous power required in our largest and swiftest steamships over two or more sets of engines, shafting, and propellers, the superior propulsive efficiency of twin-screws still remains a matter for serious doubt. Exhaustive experiments were made in France about four years ago, at the instance of M. de Bussy, to ascertain whether multiple screws would so interfere with each other as to give bad results in steaming. These experiments went to show that, for vessels of suitable form, the use of three screws, having a ratio of pitch to diameter differing but little from that ordinarily in use for vessels having single or twin screws—one in the center, placed just before the rudder, and one at each side, some distance in front of the center one—gives results from the point of view of speed very nearly equivalent to two screws of the same propulsive surface and immersed to the same depth. Whether or not this may be taken as conclusively representative of the comparative efficiency of two and of three or more screws, there can be no doubt it goes far to justify the employment of twin-screws in large full-power vessels, even from the point of view of propulsive efficiency. Efficiency apart, however, the chief obstacles which have hitherto been in the way of the adoption of twin-screws in vessels of moderate power have partaken more of a commercial than a scientific character. These obstacles comprise the necessity for duplicate sets of engines with all their various parts and complicated details, the great additional first cost, the more expensive up-keep, the extra engine-room staff entailed, and the extra space taken up in the vessel. Of these several objections, the principal ones—those which relate to extra weight and cost, extra space taken up, and extra engine-room staff—are attempted to be met by an invention recently patented by Mr. Hugh Dunsmuir, of the firm of Messrs. Dunsmuir & Jackson, Govan Engine Works, Glasgow, who are about to fit it in two light-draft vessels for Indian river service. This is an arrangement for working multiple screw propellers by means of one set of direct-acting engines placed athwartship in the vessel to be propelled.—*The London Engineer.*

Big Guns.—At a dinner of the members of The Institution of Naval Architects, Lord George Hamilton, the First Lord of the Admiralty, argued in favor of the heavy ordnance, about which there has been considerable unfavorable comment of late. In defending these guns he said: "The one object of all naval and of all military tacticians is to concentrate force on a given space and within a given area; and they do so because they believe that not merely the material destruction which the concentration of fire effects, but the moral effect of the damage which it does is of enormous importance. . . .

"The moment we come to ordnance of such a caliber as a projectile which cannot be lifted by one or two men, so far as rapidity of fire is concerned it is almost immaterial what is the size of the gun. There is little difference between the rapidity with which the 35-ton gun and the 110-ton gun can be loaded, for the mechanical engineer supplies appliances by which every gun can be loaded and reloaded with almost equal rapidity. In certain quarters there is a great wish that we should substitute manual effort for mechanical power in loading guns of a certain caliber."

Lord George Hamilton considered that all the objections against loading and training guns by mechanical power are a mere reproduction of the objections which were urged against the substitution of steam for sail power. Mechanical power may occasionally break down, but the speaker believed there was no machinery on board a man-of-war so unlikely to break down as the hydraulic power by which the great guns are loaded and trained. But if mechanical power be substituted for manual power in loading, the men must stand level with their guns, and protection must be afforded them, otherwise they can be swept away by the smallest gun. This means adding extra weight and offering a much larger target to the projectile of the enemy.

Color-Blindness at Sea.—In a paper on the Washington Maritime Conference Rear-Admiral P. H. Colomb, R.N., said: "The Conference dealt wholly with the question of color-blindness, on account of its danger with reference to the red and green side lights. I never knew, myself, a case of collision where color-blindness was in question. The statements are generally perfectly clear that wrong helm was given deliberately in the face of the color seen; and as no authoritative teaching has existed to show that it mattered what color was seen as long as danger was denoted, I have never been able to lay stress on the color-blind question."

Light Railroads.—Among the light railroads in use must now be counted a system devised by a Swedish engineer, Herr Axel F. Hummel, which is being adopted in Scandinavia, there being over 300 miles in use. For instance, on the Kosta-Lessebo Railroad, joining the Carlscrona-Vexio, Railroad the width of the gauge is 24 in., the steel rails having a weight of 18.2 lbs. per yard. The width of the formation is 9 ft. 3 in., and the radius of the curves mostly under 300 ft., and some not more than 70 ft. The gradients are as much as 1 in 35, and this has enabled the constructors to dispense with costly works. In spite of the steep gradients and sharp curves, 12-ton compound locomotives are used, having four cylinders and eight directly-driven wheels, and these are capable of hauling a train loaded with 40 tons at a speed of 15 miles an hour. The engines are provided with tenders, and a pressure of 165 lbs. is used. The trucks load from four tons to five tons, their own weight being one ton to 1.3 ton. The average cost of these railroads is given at $6,700 per mile. In Norway a railroad is to be constructed upon this system, 48 miles in length, from Christiania to Roken, but the value of the land will in that case make the estimated cost $16,100 per mile.—*The Engineer.*

Forced Draft in the British Navy.—Of a recent discussion of this subject at the meeting of the Institution of Naval Architects, *The Engineer* says: "The use of forced draft is now to all intents and purposes prohibited in the Navy," and "at sea it is in her Majesty's Navy a total failure." The nature of the failure is that the tubes all leak at the combustion chamber end if the fires are urged by fans beyond a certain point. One of the speakers, Admiral de Horsey, in the discussion of the subject, said: "The use of forced draft was now totally prohibited in ships-of-war, except under conditions of great emergency, and then it was only to be used for a very short time."

Railroad Accidents in Michigan.—The report of the Michigan Railroad Commissioner for 1889 says that on the railroads of the State during that year 160 persons were killed—of whom 7 only were passengers, 63 railroad employés, and 90 other persons—and 365 were injured, the list including 21 passengers, 256 employés, and 88 other persons. There were thus casualties to 28 passengers, 319 employés, and 178 other persons; a total of 525. The causes are shown in the following table:

	Killed			Injured		
	Passengers.	Employés.	Others.	Passengers.	Employés.	Others.
Collisions	....	....	....	....	2	....
Derailments	....	4	....	5	16	....
Coupling cars	....	10	....	....	144	....
Falling from trains	3	15	....	4	25	....
Getting on and off trains	2	5	3	6	11	3
Overhead obstructions	....	....	....	....	1	....
Miscellaneous	2	28	5	6	56	3
Trespassers on trains	....	....	11	....	1	30
At highway crossings	....	....	19	....	...	22
Trespassers on track	....	1	52	....	....	30
Total	7	63	90	21	256	88

On these figures the Commissioner makes the following comments:

"We have to report but two injuries from collisions, a decrease of 20 from the previous year, and the hope that we expressed for such a result in our last report has been satisfactorily fulfilled. From derailments 25 persons were injured, as against 20 in 1887.

"The casualties from coupling cars continue to increase, notwithstanding the exertions being made by nearly every company in the land for their prevention. For the year under report we have an increase of 13.

"Notwithstanding every effort by this office for the prevention of accidents at highway crossings, the number continues to increase, and we have a record of 19 persons killed and 22 injured, as against 15 killed and 22 injured in the preceding year.

"Falling from trains continues to be a prolific cause of fatality on our roads, 18 having been thus killed and 29 injured during the past year, of which number 7 were passengers and 40 employés. The sad commentary upon this record is that in nearly every case the death or injury resulted from the neglect or want of caution on the part of the sufferers themselves.

"Two passengers, 5 employés, and 3 others were killed, 6 passengers, 11 employés, and 3 others injured in attempting to board or leave trains while in motion—a total of 30 persons killed or crippled for lack of thoughtful care and discretion.

"For the want of wholesome legislation which would authorize, under proper restrictions, the arrest of persons found trespassing on railroad properties, there is no abatement in the work of their taking off. There were 123 of that unfortunate class run over last year and either killed or maimed for life; an increase of 15 over the previous year."

A Water Telephone.—An instrument of this kind was recently patented in England by W. Walker, of London.

In apparatus employed for the collection of sound transmitted through water, such as between ships, some difficulty is experienced in properly recording the sounds on account of the instrument being worked by other causes, such as the movement of the ship. The inventor remedies this defect by constructing the apparatus so that any pressure caused by the increased density of the water has no effect upon such apparatus. Referring to the illustration, the telephonic receiver *C* is secured concentrically within the cup *D*. By a passage *E* the cup *D* communicates with a closed tube *F*. Passing through the tube *F* is a second tube *H* having at its upper end an orifice *I*. One end of the tube *H* leads to the chamber *C*, and the other to a pressure gauge on the ship. *A* is the diaphragm of the receiver. The action of the apparatus is as follows: Assuming the same to be applied to a ship, any alteration that takes place in the position or motion thereof will cause a difference in the external pressure acting upon the diaphragm *A*, which is counterbalanced internally by the pressure of air in the chamber *C* and tube *H* caused by the water rising in the chamber *F* in proportion to the depth to which the instrument is immersed. This compen-

FIG. 1

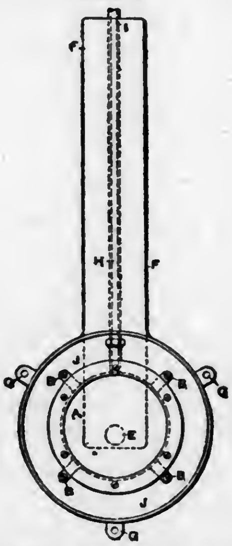
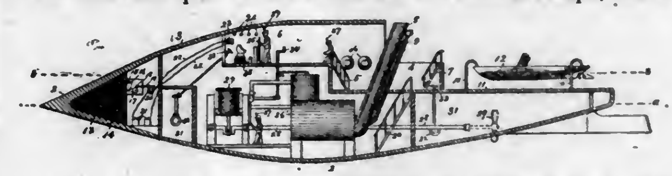


FIG. 2

sation takes place each time the apparatus is raised or lowered by the motion of the ship in the water, and ensures only the sound waves affecting the diaphragm. The area of the space *J* through which the water enters to the chamber *F* being equal to the area of the diaphragm *A*, an equal pressure acts upon each when the instrument is so placed as to receive the full force of the water through which it is passing, or which is passing it; by this arrangement the equilibrium of the diaphragm is maintained.—*Industries.*

A Self-Destructive War-ship.—The accompanying illustration shows a torpedo boat invented by Samuel Barton, of New York, and recently patented by him, the number of the patent being 423,405. It is substantially a huge torpedo, provided with engine and boiler and carrying a crew, and is also provided with a steam launch by which the crew may make their escape after bringing the ship into action.

The forward part of the vessel is of a conical shape, but at



the back end is a flat deck, upon which the steam launch is carried. The roof or deck is of sufficient thickness, in combination with its circular shape, to prevent damage from shells. The charge of dynamite or other explosive is carried in the bow at 13 14, and the charge may be exploded by electricity, means for that purpose being provided, or by the impact or shock of striking. The greater part of the rest of the space is taken up by the engine and boiler, for as it is not expected to make long trips it is not considered necessary to carry any large supply of fuel or stores. In action the vessel would be first taken to a convenient point, then submerged from the ordinary water-line *a a* to the line *b b*, then steamed at full speed toward the vessel to be attacked. The crew would then take their places in the steam launch, leaving only the pilot and the officer charged with completing the circuit for the explosion in the vessel. The electrical connection may be so arranged that the act of striking the vessel attacked would explode the charge. The pilot and his associate having remained on board until the last possible moment would jump overboard, and, being provided with life-preservers, could be picked up by the launch. The inventor claims that a very heavy charge of explosive could be carried in this way, and that the explosion, while it would of course destroy the vessel itself, would also destroy the largest iron-clad afloat. The risk, of course, is great, but he believes that it would be possible for all the crew to escape. This may perhaps be considered as a revival, with modern improvements, of the fire-ship employed in former times; at least it is an enlargement of the torpedo idea.

Nickel in Canada.—On a little branch of the Canadian Pacific Railroad near Sudbury, P. Q., is a nickel mine that produces more nickel, it is said, than the entire market of the world calls for. It is found at a depth of about 300 ft. below the surface, in a layer of oxidized Laurentian rock characteristic of that region. Immediately the mineral is hoisted from the mine it is broken up and calcined, or roasted, for the purpose of eliminating the sulphur it contains. When this process is completed, the residuum is conveyed to the smelter. After the dross of the molten metal flows off, the nearly pure nickel and copper are blended together, forming an alloy, 70 per cent. of which is nickel and 30 per cent. copper, which is drawn off at the base of the furnace and allowed to cool. When cold, the product is shipped to Swansea, Wales, and Germany, where the constituent metals are separated and refined by secret processes, known only to the manufacturers and jealously guarded. The output of the mine is stated at 4,000 tons of nickel annually.

Aluminium.—The wonderful qualities of this metal are more or less well known, the principal of which are comparative lightness, great ductility, and its anti-corrosive nature. Hitherto, it has not been extensively used, owing to its high cost, but now aluminium brass, bronze, and ferro-alloys are sold at comparatively low prices, and it appears probable that there will shortly be a revolution in the manufacture of some of the materials used in marine engineering and shipbuilding.

Recently Mr. J. Farquharson, for 30 years with the British Admiralty, and its chief metal expert, has made two extended visits to the works of the Cowles Syndicate Company, near Stoke-upon-Trent, and there personally made many tests and trials of the Cowles standard alloys. In his report, he states: "For bearings and all work that can be cast in chill, the bronze alloys are, in my opinion, superior to any metal previously in use. As regards the brasses, composed of copper, spelter, and aluminium, they have properties which make them comparable with gun metal and other bronzes used as cast, rather than with the brasses proper, mainly composed of copper and spelter;" and in his opinion they are, as regards reliability, strength, and stiffness, greatly superior to all other alloys in use. The No. 2 aluminium brass is, he states, the best metal for screw propellers, stern-posts and stems of ships, at present known, and is remarkable for the qualities required in such work, having a tensile strength as cast, as high as 34 tons per

square inch, with an elastic limit of 26 tons, and yet capable of standing severe blows without breaking.

It is not, however, in combination with copper, that the greatest use of aluminium may be expected.

When a small percentage in the form of ferro-aluminium is added to cast-iron, or in the puddling furnace, most remarkable results are obtained. Recently, a considerable demand has arisen for ferro-aluminium for foundry use, as the addition of small percentages of aluminium up to 1 per cent. has been found to improve the quality of cast-iron, and to permit the production of faultless castings from iron hitherto regarded as altogether unfit for foundry use. Similarly, the addition of only 0.25 per cent. in the puddling furnace has led to most satisfactory results. Comparative tests of ordinary puddled bars of iron, and of bars rolled from the same quality of iron, but with the addition of 0.25 per cent. of aluminium, in the form of ferro-aluminium, show that whereas the ordinary iron had a tensile strain of about 18 tons per square inch, and an elongation of 10 per cent. in 8 in., bars having the above-mentioned small percentage of aluminium have a tensile strain of 31 tons per square inch, with 22 per cent. elongation in 8 in., and the bending tests showed equally good results.

It would thus appear that the alloys of aluminium will be found to be of increasingly great practical and commercial importance. The pure substance is still so very costly, about $3.75 per pound (the price has recently been reduced about one-half), that its sole use in shipbuilding, engineering, and boiler-making is out of the question; but the adoption of small percentages, securing great economical results in inferior metals, may be said to have been practically realized. The more general adoption of aluminium alloys for propellers, bearings of engines, etc., is also highly probable, seeing the increasing speeds at which marine and other engines are driven, necessitating more reliable materials than those hitherto in use. Similarly its alloy ferro-aluminium in iron and steel manufacture may be expected to exercise a useful function.—*The Nautical Magazine.*

A New Method of Tempering Steel—A paper on this subject was read before the London section of the Society of Chemical Industry by Mr. Watson Smith, Lecturer in Chemical Technology in University College, London. The new method in question is the invention of Captain G. Feodossieff, of the Imperial Russian Navy, St. Petersburg, Inspector of all metals used in naval construction in the Imperial arsenal. In this process, protected by letters-patent in England, glycerine is the substance or medium proposed, and it is employed for the hardening, tempering, or annealing of steel, cast steel or cast iron. The Lecturer referred to the British Association address of 1889, by Professor W. C. Roberts Austen, Chemist to the Mint, where he had referred to the confusion at present existing in the use of the words "hardening," "tempering" and "annealing" as applied to steel, the outcome being the following clear definitions: "Hardening is the result of rapidly cooling a strongly heated mass of steel; tempering, that of reheating the hardened steel to a temperature far short of that to which it was raised before hardening—this heating being followed or not being followed by rapid cooling; while annealing consists in heating the mass to a temperature higher than that used for tempering, and allowing it to cool slowly." Captain Feodossieff proposes to vary the specific gravity of the glycerine to be used from 1.08 to 1.26 at 15° C. by the addition of water, according to the composition of the steel and the effect desired. The quantity of glycerine is to be from one to six times greater in weight than that of the pieces to be plunged into it, and, in accordance with the hardening of the metal, its temperature is to be varied from 15° to 200° C., a high temperature being employed for the tempering of the harder steels, while a lower temperature is used for tempering the milder steels. Additions of various salts to the glycerine baths are recommended to increase their quenching power. Thus, for a hard temper, manganous sulphate may be added in quantity varying from 1 up to 34 per cent. of the liquid, or from ½ to 4 per cent. of potassium sulphate; for a softer temper, 1 to 10 per cent. of manganese chloride, and 1 to 4 per cent. of potassium chloride may be added.

Articulated Compound Locomotives.—The Swiss Central Railroad has ordered several four-cylinder Mallet articulated compound locomotives. The new Swiss tank engines will be carried on eight wheels, coupled in two groups, driven each by a separate pair of high and low-pressure cylinders, while the front or low-pressure group is made to swivel as a bogie. The weight of an engine, fully equipped, will be 52 tons, or 13 tons per axle.

A London City Railroad Station.—The accompanying sketch shows one of the six stations now being erected along the route from King William Street to Stockwell by the city of London & Southwark Subway Company. All the edifices vary in plan and arrangement, but the exteriors possess some common features. The principal one is the great circular shaft down which the passengers will be taken to the railway below. The domes will not only be important landmarks for the public, but will also serve to take the wheels and gear with which the elevator will be worked.

It was proposed to use copper for the external covering, in order to secure not only increased durability but also the poetic charm of coloring incidental to the use of this material. The expense was, however, found to be too great, and the domes are being excellently covered with Vielle Montagne zinc, without the use of solder.

The stations are being built of red brick and Bath stone. The entire works are being carried out by Messrs. J. Simpson & Son, under the superintendence of the architect, Mr. T. Phillips Figgis.—*London Railway Press.*

Six-Cylinder Triple-Expansion Engine.—The Fall River Iron Works mill is driven by a six-cylinder triple-expansion Corliss engine, or perhaps it may be better described as two complete tandem triple-expansion engines attached to opposite ends of the same shaft. It is rated at 1,300 H. P. when running at the rate of 65 revolutions per minute, and with 150 lbs. initial pressure. The high pressure cylinders are 16½ in. in diameter, the intermediate 28 in., and the low pressure 42 in., the stroke being 5 ft. The fly-wheel is 28 ft. in diameter, 114 in. on the face and carries four belts, two of which are 32 in. in width, one 26 in. and one 16 in. The pulley weighed, when finished, 97,728 lbs. The cylinders are steam jacketed and cased in sheet metal instead of the usual black walnut lagging. The wrist plate is superseded by the more modern arrangement now used by the Corliss Company, securing a more rapid movement to the valve. Each cylinder is provided with the Corliss Company's new release valve, allowing for the escape of entrained water. This consists of a long flat steel spring, the ends of which press upon valves located in the back bonnets of the exhaust ports. An excessive pressure, such as would be generated by the confinement of water in the cylinder, lifts these valves against the action of the springs and allows the water to escape. The engines have been in continuous operation since October 15, 1889, and develop 1,400 H. P.—*Providence Journal.*

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THE latest Rapid Transit Commission in New York appointed under the old law, has ended its labors by a simple recommendation for an underground line extending from City Hall to the Grand Central Station in Forty-second Street, following the line of existing streets, with two short cuts through private property. This is hardly a solution to the problem, since a line to Forty-second Street only would be of very little account in improving the present means of transit; but it may be useful if an arrangement can be made for working it in connection with the tracks of the New York Central & Hudson River Railroad north of the Grand Central. Possibly it is the best that the Commission could do, since its action was so limited by certain provisions of law that a better result could hardly be expected. As the matter stands now, it is very probable that the work of the Commission and its recommendations will practically result in nothing.

THE sharp competition between the Pennsylvania Railroad and the Baltimore & Ohio has led to the reduction of the time of the fastest trains between New York and Washington to about five hours on both lines. For a distance of about 225 miles, with considerable deductions to be made for the ferry at New York, grade crossing stops, the passage through Philadelphia and Baltimore, it will be seen that this time requires running faster than has yet been seen in America for regular trains, and indeed a speed which is not exceeded anywhere.

THE acquisition of the St. Louis & San Francisco lines by the Atchison, Topeka & Santa Fé Company is another step in the process of railroad consolidation which is constantly going on. The Atchison Company now claims the largest system, since it controls very nearly 9,000 miles of road, or about one twenty-fifth part of the total mileage of the United States.

The transfer is a natural one, as the two companies had many joint interests and their lines are so connected that any hostility or even serious difference between the two managements would have made much trouble for both. It has been made by the purchase of the St. Louis & San Francisco stock by the Atchison Company, in exchange for its own issues.

THE narrow gauge is gradually but steadily disappearing. The latest railroad to abandon it is the Anniston & Atlantic, a line 53 miles long in Alabama, which has just completed its change from 3 ft. to standard gauge.

The longest narrow-gauge line in this country—the Denver & Rio Grande—is making steady progress with its change to standard gauge, and will before long entirely abandon the 3 ft. gauge.

IRON production, which has been very large all the year, continues to increase. The report of the *American Manufacturer* shows that on June 1 there were 340 furnaces in blast with a weekly capacity of 181,953 tons, which is a decrease of one furnace, it is true, but an increase of 1,000 tons in the weekly production, during the month of May. Quite a number of changes were made in the list during the month, but with the general tendency to increase rather than diminish production, the furnaces which have gone out of blast having stopped mainly for repairs or other necessary causes, while their places have been more than filled by those which have gone into blast. It seems probable that the pig-iron production for the year will show a considerable gain even over the large figures of last year.

IN consequence of the illness of Professor Jameson, we are compelled to omit this month the usual installment of the articles on the Use of Wood in Railroad Structures. Their publication will be continued, however, in the next number, when several plates will be given with the usual description.

ENGLISH AND AMERICAN LOCOMOTIVES.

LAST winter a number of the locomotive builders in this country received an invitation, through the Engineering Committee of the Edinburgh International Exhibition, to send a representative express locomotive to be exhibited there, and have it subjected to a competitive trial with a similar engine built on the other side. This invitation was declined. In commenting on this a short time ago, the *Engineer*, unfortunately and unwittingly referred to our national emblem as the "stars and bars." This excited the patriotic wrath of our contemporary, *Engineering News*, and on February 8 the Editor of that paper replied with a good deal of acerbity, and wound up by conceding that "in hauling light trains at high speed over the most costly and perfect track, with moderate consumption of coal, an American locomotive might not do quite so well as an English one." But, the writer in that paper says further, "when it comes to hauling very heavy trains, especially maximum trains, at slower speeds, or to coal consumption per ton mile or passenger mile, or to cost of repairs for equal loads, or long mileage per year and between repairs, or to service on slightly inferior track—here, we think, the English locomotive would compare to poor advantage."

The editor of the *Engineer* then apologizes for calling the stripes of our flag "bars," thanks our contemporary for the admission that in hauling light trains at high speeds they can probably beat American engines, and for its side "admits" that in engines with eight, ten or twelve

wheels coupled English engines "make no show," but this, it is said, is simply because they do not want to make a show. The *Engineer* goes on to say that "there is a certain proportion of goods hauling done in the United States with engines of much the same general dimensions as those used in this country, and it is quite possible to institute a comparison between these two types." Our foreign contemporary then invited his American brother to give a definite statement of the advantages possessed by the American locomotive over the English, and "explain precisely in what way and how the American engine is a better all-round machine than ours;" and it says further that, "we would ask our contemporary, to begin with, to confine his attention to one feature at a time, and we suggest that it should take boilers first, and the whole practice of making steam and the method of firing with bituminous or semi-bituminous coal, comparing English and American methods together, pointing out the defects of the former and the advantages of the latter."

In its issue of March 15 the *News* accepts the *Engineer's* apology for disrespectful mention of the stripes in our flag as "bars," and also its challenge to show that the American locomotive is a better all-around machine than its English cousin. But, the Editor of our American contemporary adds, we will allow "ourselves" some little time before doing so. The decks, therefore, have been cleared for action, but up to the date at which this is written the cis-Atlantic adversary has not fired a gun.

The issue, it will be seen, is narrowed "considerably," it is "allowed," by the one party in the contest that "in hauling light trains at high speeds they (the English engines) can probably beat ours." On the other hand, the British adversary admits that in engines with eight, ten or twelve wheels coupled, "they make no show." In this he is like Dickens's character, whose room was disparaged because it was not big enough to "swing a cat in," and who vindicated it by saying that he "didn't want to swing a cat." So the *Engineer* says, in what he calls "caterpillar engines" they "don't want to make a show."

The issue, then, seems to be narrowed down to the challenge of the *Engineer* to "explain precisely in what way and how the American engine is a better all-round machine than ours."

As remarked before, up to the date of writing our New York contemporary has remained silent. In the meanwhile, the *Railroad Gazette*, probably, as the other party to the contest remarks, tired of waiting, has come forward to defend the American locomotive against all comers, and the first of two articles appeared in its issue of April 25. The first half of this article is devoted to showing the impossibility of making a comparison of either the performance or economy in cost of repairs of engines working in different countries under diverse conditions; and it says, "On foreign roads, for which both English and American designers have been called upon to supply engines such comparisons are possible." The *Gazette* intimates that the fact that American engines have been largely sold to such countries is proof of their superiority, and that they, long ago, ran English locomotives out of Canada is conclusive as to the merits of the former.

To the first argument the *Engineer* replies that the reason why "American locomotives have in certain cases been bought for our colonies, instead of English engines, . . . results . . . from causes which possess no scientific interest," and refuses to discuss them. It must be admitted that the *Gazette's* argument, or rather its citation of facts, is a little tottering. If a medicine maker should advertise that a sick man had taken his Patent Panacea, and had been much benefited thereby, but at the same time it should appear that the convalescent had also swallowed an equal or a greater quantity of the Universal Remedy, it might be a question whether the Panacea or the Remedy cured the patient. The Canadian argument is better, and it remains for our foreign contemporary to explain why on Canadian roads which were first equipped with English locomotives they have been displaced entirely by those of American design.

The *Engineer*, however pulls itself together here, and counters with the remark that "neither the *Gazette* nor any other American authority will condescend to say specifically in what the fitness (of American locomotives) consists that has led to their survival." Our British contemporary had not yet heard from *Engineering News* when it wrote those brave words. The *Engineer* shouts vehemently, "Our locomotives burn less coal than yours do." The *Gazette* answers, "What if they do; we pull more than you can." From across the Atlantic comes the interrogation to us, "What do your locomotives cost for repairs, anyway?" and the *Gazette* answers ruefully, "We don't know, but we intend to know;" and with real Yankee interrogative retaliation asks, "What do yours cost?" and their adversary replies, "We don't know either;" and they then proceed to write long arguments based on what they don't know.

The *Gazette* then "goes in" again and says, "You admitted, on March 14, that your stationary steam engines were defective in workmanship, which shows that your locomotives are "no good." This, the *Engineer* says, is not fair, and that in the article referred to they did not mean locomotives, but stationary engines; that when the Webb engine arrived at Altoona all the leading officials in the locomotive department were sent for, that "they might see what really first-class work was like." In a "critical" article published in the issue of February 28 the *Gazette*, unfortunately for its side of the discussion, "frankly told the defects of some American locomotives," and, as its opponent asserts, "said more hard things of American practice than we ever dared to say." Admissions like these often rise up before us like ghosts and then become

> "As the air, invulnerable
> And our vain blows, malicious mockery."

In this instance another ghost, in the form of a sample English locomotive sent to the Western Railway of France, which, it is said, had to be nearly rebuilt after running a short time, was called up by the *Gazette* to lay the specters that were let loose on February 28.

In its second article, the *Gazette* mentions the valves on the inside of cylinders, crank-axles, lack of facility in oiling, absence of means of adjustment of driving-boxes, as defects in English engines. The reply made to these charges is that the *Gazette* "asserted that the exhaust in this country is very much throttled in inside cylinders, and yet he states in another place that English engines are free from the hindrance of a throttled exhaust, to which American engines have to submit to blow their fires." As the American editor knows little about crank-axles, it is said that "it would be perhaps too much to expect a valuable expression of opinion." If our contemporary had referred to the Returns of Accidents by the British Board of Trade, they would have learned there that in 1885 190 crank or

driving axles were broken in the United Kingdom, 210 in 1886, 145 in 1887 and 112 in 1889.* The other defects of English engines which have been enumerated by the *Gazette* are passed over by the *Engineer* with derision. But our foreign contemporary has not, it is to be feared, measured its other, thus far silent, foe. The quiescence of *Engineering News* since last March has probably not been purposeless, and may be portentous.

The discussion recalls a venerable story of what occurred down in Kentucky on a certain election-day, when the arguments employed were forcible but not convincing. After the event the participants were brought up in court to answer for their indiscretions, and a certain Jim Bludsoe testified that while the fight was going on he and his friend Sassy Hammet was "a-sloshin' round." The judge asked him to explain. "Well," he says, "you see, Hank Smith, he was a-holden Country Jake down with his nose between his teeth, and that feller what keeps the tavern had young Millican's head under his arm, and was doin' his best to improve his looks, and Sassy and me was sloshin' round." But the court asked, "What do you mean by '*sloshin' round*'?" "Well, you see, jedge, there was a pile of fellers in the middle of the fight, which was piled up about six deep, and they was a-scratchen and a-butten and a-biten and a-hitten each other, and we was a-*sloshin' round*—that is, wherever we seed a head that was loose we hit it." Now, after *Engineering News* opens its guns, if Edward Bates Dorsey would only step in and take a part in this delightful controversy and begin "sloshin' round," the entertainment will become complete. The *Engineer* will wish it had never been born, the American locomotive will distend its nostrils, and declare itself victorious with a shriek which will be heard from Alaska to Patagonia, and will penetrate either diametrically through the earth or be wafted circumferentially around it to our antipodes, who, standing on their heads, may be able to comprehend the significance of the arguments.

THE CAR BUILDERS' AND MASTER MECHANICS' CONVENTIONS.

THE attendance at the two meetings just held at Fort Monroe was larger than it has been any year heretofore, and the interest in them showed no signs of abatement. There was, however, a general demand from those in attendance that some arrangement should be made for holding the conventions so that less time will be consumed in attending them both. Those persons having charge of both the car and locomotive departments, who are interested in the proceedings of both Associations complain—and with good reason—that they cannot give two entire weeks to these meetings. As a consequence of this outcry each Association has appointed a Committee of conference to make some mutual arrangement, if it is possible to do so, for holding the two meetings, so as to occupy less time than they do now. At present one of the Associations holds its first session on Tuesday and its meetings generally continue through Wednesday and Thursday, the final adjournment occurring on Thursday afternoon. There is then an interval of Friday, Saturday, Sunday, and Monday, until the following Tuesday, when the first meeting of the other Association is held. This interval is long and tedious to those who remain for both conventions. It was therefore proposed that the first session of one of the Associations should be held on Wednesday, and the following ones on Thursday and Friday, and that the meetings of the other body should meet on Monday and occupy that day and Tuesday and Wednesday. This would reduce the time two days. There are, however, some objections to this plan. There would still be an interval of two days between the meetings, and the time occupied from the opening of the one convention to the close of the other would be *eight* days instead of *ten*, as at present. Past experience has shown, too, that it is almost impossible to get a good attendance of members at a meeting held on Monday. Those who must come any considerable distances have a disinclination to start from home on Sunday morning, and they assume—as is partly true—that the opening session will be less interesting than the succeeding ones, and they arrange to arrive at the place of holding the meeting on Tuesday morning.

Besides these objections, the plan proposed will still consume most of the time of two whole weeks.

Another plan which has been suggested is that one of the Associations should hold its first session on a Monday evening. Most of the members could then reach the place of meeting by leaving home on Sunday night, or those near to it could do so by starting Monday morning. The opening exercises could be held, the President's address heard, the reports of officers received, and other routine business transacted. It is not of great importance whether the attendance at these proceedings is very large or not, but they always consume a great deal of time, and if they were disposed of during a preliminary evening meeting it would leave the table clear at the following session on Tuesday morning. The whole of Tuesday and Wednesday, without any routine business, would in most cases be sufficient for the ordinary proceedings of either convention. The other Association could then hold its first meeting on Wednesday evening, and have Thursday and Friday clear for its other sessions. The two meetings would thus occupy *four* days' time instead of *ten*, as at present, or *eight*, as would be required by the other proposed arrangement.

As some sort of excursions and entertainments seem to be inseparable from these occasions, the four-day plan would permit the members of the one body to amuse themselves during two days while those of the other are in session. If for any reason the organization which meets first could not complete its business in the time allotted to its meetings, there is nothing to prevent it from continuing its sessions after the other meets—in other words, the Associations could hold meetings simultaneously if there was occasion for doing so.

The only difficulty to be anticipated would be a lack of adequate hotel accommodations if both organizations held their meetings so near together. This could be provided for by judiciously selecting places where the hotels are large enough.

COLD WATER WITHOUT ICE.

THE following method of obtaining a constant supply of cool water at all times is in general use in Hanover, York County, Pa. The town is built over a stratum of limestone, so that the water is "hard," or impregnated with lime. The town is also closely built up and without any system of drainage, so that the water from the wells is unfit to

* The reports unfortunately do not say what proportion of those broken were crank-axles and how many were straight, but, owing to the large proportion of inside cylinder engines in use on British roads, the larger proportion of those broken are doubtless crank-axles. Our report for 1888 is unfortunately missing.

drink. Some years ago these reasons led to the introduction into the town of a supply of very excellent water from a large spring about three miles distant. This water is brought through iron pipes, and when it reaches the consumer in summer is warm, while the water in the wells is cool. For this reason many of the inhabitants drink the well water, and as a consequence typhoid fever is a prevalent disease in that community. In order to obtain pure cool water, not impregnated with lime, some of the inhabitants of the place have adopted a plan which is so simple and gives such excellent results that it is worthy of general adoption wherever there is a water supply other than wells or springs. The plan is as follows: a cylindrical galvanized sheet-iron tank, 12 in. in diameter and 4 ft. or 5 ft. long, is placed in the bottom of a well. This tank is then connected by a galvanized iron pipe with the water supply pipes, and another pipe is carried from the tank to the surface of the ground or to any convenient point for drawing water, and has a cock at the upper end. The tank is consequently always filled with water from the water supply, and being in the bottom of the well, the water is cooled off and acquires the temperature of the well; so that that which is drawn from the tank is as cool as well water, and is without any of the impurities with which the latter is contaminated. The water drawn from the tank in one of the wells in the place named had a temperature of 56° when the thermometer in the atmosphere above stood at 76°.

This method gives an abundant supply of cool water during the whole summer, and can be adopted in all cities, towns or in the country. If a well is available, it can be used; if not, by simply digging a hole in the ground, deep enough so as not to be affected by the surface temperature, and burying the tank, it will answer equally well. This hole might be dug in a cellar or outside the building. If the water has any impurities in suspension, such as mud, the tank should be made accessible so that it can be cleaned occasionally. It is a common practice in cities for people who cannot afford ice in warm weather to use water from wells which are little used at other times. The water in these wells is nearly always contaminated with dangerous impurities. If a tank was placed in them and arranged as described it would give a supply of cool and pure water. Water from cisterns, if above the surface of the ground, can be cooled in the same way.

SMOKE PREVENTION.

THIS subject, like poverty and taxes, we have always with us. In the cities west of the Allegheny Mountains, where bituminous coal alone is burned, it is becoming of growing importance, and even in New York many tall chimneys now throw out black clouds, showing that the use of the same fuel is becoming common there. In England the subject has attracted most attention, and for many years past has been legislated about and investigated until the subject has been darkened by the magnitude and extent of the efforts to throw light on it.

The English technical papers tell us that a well-attended public meeting, convened by the Lord Mayor of London, was recently held to promote the work undertaken by a committee for testing smoke-preventing appliances.

The perplexing feature of the whole subject is that for fifty years or longer English and American engineers have been doing their best to prevent smoke *economically*. It can be and has been prevented, but the difficulty is that it costs more than it is worth. At this meeting the Mayor of Rochdale said:

> He did not find it so easy to consume smoke as Mr. Hart had said; in fact, after trying for 40 years, he had not yet succeeded. There were firms in Rochdale who, having spent hundreds of pounds in endeavoring to consume their own smoke, were now taking out their smoke-consuming appliances, because they did not succeed.

Another speaker expressed the opinion that perfection had not yet been reached in the matter; and a third said:

> What was wanted was not new experiments or new tests, but the adoption of existing resources, which it had been conclusively proved were sufficient to prevent smoke in any manufactory of any kind or size.

The Earl of Derby, after some very interesting remarks, said:

> Since this meeting was called I had a visit from a tenant on my own estate, renting collieries from me, and he declared that for 13 years he has worked on the principle of suppressing smoke entirely, that he has found it practicable, and more than that, that he has made it pay.

Now, if the latter statements are true, if some of the English engineering papers would describe fully the "existing resources," which one speaker says "it had been conclusively proved are sufficient to prevent smoke," and the method in use by the Earl of Derby's tenant, such descriptions would be of very great interest to the much smoked inhabitants of some of our Western cities, and doubtless to many of the same class of people in England.

NEW PUBLICATIONS.

PAVEMENTS AND ROADS: THEIR CONSTRUCTION AND MAINTENANCE. REPRINTED FROM THE *Engineering and Building Record:* COMPILED BY E. G. LOVE, PH.D. New York; published by the *Engineering and Building Record,* No. 277 Pearl Street (price, $5).

This book is a compilation of articles on the subject which have appeared in the *Engineering and Building Record;* these articles have been edited with a view of eliminating such matter as might be only of local or temporary interest.

The book is divided into three parts. Part I treats of street pavements, containing chapters on Stone Pavements; Wood Pavements; Asphalt Pavements; Brick Pavements; Curbs, Sidewalks and Tramways; Street Opening and Maintenance, and Notes of Experience. Part II treats of the Construction and Maintenance of Roads, and Part III contains the prize essays on the same subject which were submitted in a competition instituted by the *Record.*

The book contains a large amount of valuable information collected from various sources, including records of experience with pavements of various kinds, methods of construction and maintenance adopted in this country and in Europe, and other matter of a similar kind; most of it practical and easy of application. It is on a subject upon which information is much needed, and which has been too generally neglected in this country, and the book is therefore likely to be of much service to engineers. Of course, a great part of the information was already in existence, but not in a shape to be readily accessible to those who needed it; and it is also a fact that this treatise is the first American work on the subject which has appeared in a considerable time.

Among the chapters claiming especial note are those on Asphalt Pavements; on Brick Pavements, and on Curbs, Sidewalks and Tramways. The specifications given for asphalt will be found worth noting, as will also those for wood paving and for paving materials.

The book contains 410 pages, and is published in good shape, though a little more liberality in the matter of illustrations might

be desired. It is well worth a careful reading by all who are interested in the subject.

BANKERS' AND BROKERS' REFERENCE BOOK: BY ALFRED SMITH. New York; the American News Company.

In this book Mr. Smith presents, by figures only, a variety of useful information for those engaged in finance, speculation and investment. The only letter-press is a brief review of the general course of the New York stock market from 1877 to date, and some notes appended to the tables. The form of the book is convenient for the desk or the pocket, it is well and clearly printed; and cannot fail to be useful to those for whom it is designed. The Editor announces that by addressing him, care of the American News Company, special arrangements can be made by brokers and others, by which the book will be furnished in quantities with the name of the house wishing to use it for customers or for advertising.

MACHINED CAR WHEELS. Issued by the New York Car Wheel Works, Buffalo, N. Y.

In describing the current trade catalogues, one finds that the supply of adjectives for describing their luxurious character fail to be equal to the demand. We have before us a pamphlet of 30 pages printed on plate paper in the handsomest style of the printer's art. The cover is of heavy white coarse-grained paper, which looks like that made by Whatman for water-color drawing. It is to be feared, though, that its beauty is quite too delicate to be preserved in many of the places for which it is intended.

The matter of the pamphlet describes the evolution, use and merits of "Machined" Car Wheels as made by its publishers in their works in Buffalo. It describes the methods and processes by which cast-iron chilled wheels, which are ground so as to be perfectly true on their treads, can be furnished at prices very little, if any, above those of a first quality of unfinished wheels; how the character of the work has improved, and the advantages resulting from this perfection; and is an illustration of how railroad appliances are gradually being perfected. Every railroad manager, but especially car-builders, should read it.

BOOKS RECEIVED.

HANDBOOK OF PASSENGER TRAFFIC AND ACCOUNTS: BY MARSHALL M. KIRKMAN. Chicago; published by the Author. This book is received too late for proper comment in this issue.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; published by the Institution. The present installment of these valuable papers includes Recent Dock Extensions at Liverpool, by George F. Lyster, with abstract of the discussion on the paper; Bars at the Mouths of Tidal Estuaries, by James Forrest, also with abstract of discussion; Abstract of Papers in Foreign Transactions and Periodicals.

THE MICHIGAN ENGINEERS' ANNUAL: PROCEEDINGS OF THE MICHIGAN ENGINEERING SOCIETY FOR 1890. Published for the Society; F. Hodgman, Secretary, Climax, Mich.

QUARTERLY REPORT OF THE CHIEF OF THE BUREAU OF STATISTICS, TREASURY DEPARTMENT, RELATIVE TO THE IMPORTS, EXPORTS, IMMIGRATION AND NAVIGATION OF THE UNITED STATES FOR THE THREE MONTHS ENDING DECEMBER 31, 1889. Washington; Government Printing Office.

CORNELL UNIVERSITY, COLLEGE OF AGRICULTURE, BULLETIN OF THE AGRICULTURAL EXPERIMENT STATION: XVII, MAY, 1890. Ithaca, N. Y.; published by the University.

SEATON MANUFACTURING COMPANY: ILLUSTRATED CATALOGUE OF BOLT-HEADERS, RIVET MACHINES, UPSETTERS, ETC. Cleveland, O.; issued by the Company.

THE WENSTROM DYNAMO AND MOTOR: ILLUSTRATED PROSPECTUS AND DESCRIPTION. Philadelphia; Chadbourne, Hazelton & Company, General Agents.

ILLUSTRATED CATALOGUE OF THE PRODUCTIONS OF THE JOSEPH DIXON CRUCIBLE COMPANY: GRAPHITE, PLUMBAGO, BLACK LEAD, PENCILS, CRUCIBLES, STOVE-POLISH, LUBRICANTS. Jersey City, N. J.; issued by the Company.

PORTLAND CEMENT FOR ENGINEERING WORKS: BY W. W. MACLAY, C.E. New York; issued by James Brand, Importer of Cements.

ABOUT BOOKS AND PERIODICALS.

IN the POPULAR SCIENCE MONTHLY for June Professor Henderson continues his interesting articles on Glass Making. M. de St. Pol Lias has an illustrated article on Tin Mining in Malacca, while Professor Griffin writes of Natural and Artificial Cements. Mr. Barr Ferree has an article on Utility in Architecture, in which the tendency to subordinate use and engineering to outside appearances is strongly criticised.

In OUTING for June the military article is on the National Guard of Vermont. As if suitable to the opening season, there are several articles on Yachting, with the usual variety on other out-door sports.

The May number of the JOURNAL of the American Society of Naval Engineers is a very practical one, as can be seen from the titles of the leading articles, which are: Notes on Modern Boiler Shop Practice, by Past Assistant Engineer A. C. Engard; Boiler Shop of the Union Iron Works, San Francisco, by Assistant Engineer W. Stuart Smith; Notes of the Effect of Temperature on Certain Properties of Various Metals and Alloys, by Assistant Engineer B. C. Bryan; Machinery of the Torpedo-boat *Cushing*, by Past Assistant Engineer Stacy Potts; Tubulous Boilers, by Assistant Engineer S. H. Leonard.

Among the many interesting articles in SCRIBNER'S MAGAZINE for June one of the best is that on the Rights of the Citizen as a User of Public Conveyances, which is by President Seth Low, of Columbia College, New York. Mr. Low makes a strong argument in favor of the municipal control of franchises for public conveyance and city traffic.

The JOURNAL of the New England Water Works Association for June contains several valuable papers, while the report of the discussions contains a number of interesting records of experience.

The article on the Caucasus in HARPER'S MAGAZINE for June gives some account of the oil wells of Baku, which are important factors in the petroleum markets of the world. Mr. Park Benjamin gives an account of the working of Lieutenant Fiske's Range-finder, a very remarkable instrument. In the Best Governed City in the World there is an account of a business-like solution of some troublesome problems in municipal government.

The first number of SCIENTIÆ BACCALAUREUS is a very creditable one; it is a "Quarterly Journal of Scientific Research," published under the auspices of the Missouri School of Mines at Rolla, and edited by the Senior Classmen of that institution. This number has articles on the Transition Curve and on Continuous Construction of the Ellipse, by Professor W. H. Echols; on the Beginnings of Mathematics, by Professor W. B. Richards; on Tallow Clays, by Professor W. H. Seamon; and on the Establishment of the True Meridian, by George R. Dean. There are also a number of problems given for solution.

In the ARENA for June, while there is no article of special technical interest to engineers, there is abundant discussion of social and ethical questions which ought to be interesting to every intelligent man.

A CAUSE OF BOILER EXPLOSIONS.

To the Editor of the Railroad and Engineering Journal:

THE experiments of F. G. Fowler, mentioned in his paper, "A Cause of Boiler Explosions," an abstract of which appears in your May number, are of the most interesting and valuable character, as they bear directly upon a class of explosions the cause of which has been largely conjecture.

Although his experiments have been in the right direction, the results and observations do not seem to bear out the theory which he advances.

Professor Tyndall, in his work, "Heat a Mode of Motion," pp. 155–58, gives a clew to the conditions leading up to these mysterious explosions, and in the light of what is there stated, let us examine and interpret Mr. Fowler's experiments.

1. In the first place, Mr. Fowler lays all the blame to the "aerated" water. It would seem rather that the rupture of "set" of the "de-aerated" water lies at the bottom of all the difficulty; for, applying heat to his small closed boiler, filled with "aerated" water and air, would liberate all the occluded air and gases from the water and lock its molecules firmly together; and it can in this condition, without increasing the steam pressure, absorb a large quantity of heat, which becomes latent. Now reverse the boiler. The tension or set of the water is relieved by absorbing the air and gases mixed with the steam, which releases the latent heat, forming steam, and suddenly increases the pressure, as shown by the experiment.

2. No increase of pressure was shown to take place when the water is "de-aerated" and relieved of the presence of air and gases. And let us see why.

A greater amount of heat is necessary to attain a given steam pressure in a boiler containing de-aerated water than is the case with aerated water, for the reason, as shown, a large quantity of heat is absorbed by the water with tightly locked molecules and held latent. Any agitation or reversing of the boiler cannot alter the condition, as nothing is present to release the tension of the latent heat. If, however, the tension be relieved by opening a valve, there should be noted an increase of pressure, as shown in the first experiment. The latter condition is analogous to that of opening the throttle valve and rapidly drawing steam from a boiler which had been for some time entirely closed.

These conclusions would also seem to be borne out by the points used in corroboration of the theory advanced by Mr. Fowler.

The prevention of explosions from this cause, then, might be accomplished by opening the blow-off valve for a few moments as soon as the steam gauge shows 15 or 20 lbs., as that will destroy the set to the water before a dangerous pressure is reached.

Mr. Fowler, fortunately, has had the facilities for making his experiments in a practical way, and not found it necessary to rely on conclusions drawn in a more or less indirect way from physics. However, he might do well to continue his researches on the lines suggested by the experiments of Professor Tyndall, and disprove, at least, their relation to the class of phenomena which he has undertaken to explain. K.

MASTER MECHANICS' ASSOCIATION REPORTS.

AT the Annual Convention of the Master Mechanics' Association a number of reports were presented by committees, all of them containing much information. The Committee on Axles for Heavy Tenders reported in favor of adopting the M. C. B. standard axle for cars of 60,000 lbs. capacity as the standard for heavy tenders.

The Committee on the Relative Value of Steel and Iron Axles—Messrs. John Mackenzie, J. S. Graham and John S. Cook—presented a large amount of information collected, but reported no definite conclusion, and recommended a further continuation of the subject.

The Committee on Brick Arches in Fire-boxes presented a report, the conclusions of which are thus summed up:

"In conclusion, your Committee find that the brick arch greatly assists in bringing about more perfect combustion, and thus aids in lessening the amount of black smoke formed, and, for the reasons already set forth, helps to consume or rather burn out the combustible parts of the gases composing the smoke that is formed, and failing to find that any serious damage results from their use, and that the first cost and cost of maintenance, as compared with ordinary diamond-stack, plain fire-box and short front, is plainly in favor of the former. We therefore recommend its use by all who desire to get the best and most economical results from bituminous coal fuel.

"We recommend as the best manner of supporting the arch that arrangement embodying as its principal features —First, freedom from any danger to those constantly employed about the engine by failure of parts, such as are sometimes attended by the use of circulating pipes. Second, one that can be quickly and cheaply, yet substantially put up and maintained, and that is in a measure protected by the arch from the action of the fire. Third, one that will allow the bricks to be removed and replaced with greatest ease and least possible damage, and that will give easy access to the boiler tubes, tube sheet and crown sheet when bricks are removed, and we think that these several conditions are nearer met by some of the methods shown on blue prints on exhibition in the meeting room, and known as the 'Angle iron and stud supports,' and we believe that the best features of some of these might be combined and worked into a support that will meet the requirements of the general service. We are not prepared to recommend the abolition of the circulating pipe, but we suggest the serious consideration of a safer and cheaper method for supporting brick arches than is obtained by their use.

"Before closing this report we desire to call attention to the large number of arch bricks broken in transit and by handling after they are received. This is especially the case where bricks are hauled long distances and when shapes are flat, long and heavy. It has occurred to us that some suitable means might be adopted to strengthen the brick by having iron rods made up in the moulds in such manner that should the bricks become cracked or broken through their section, they would be held together and could be utilized, and as soon as exposed to heat in furnace, they would fuse together from the effect of accumulated slag, etc."

The Committee on Corrosion of Water Tanks reported the results of inquiries recommending the use of good metallic paint, the sloping of the top sheets of the tank in order to prevent standing of water upon them, and the care and attention of the man running the engine. These, they think, would much prolong the life of the tank.

The Committee on Placing Fire-boxes above frames report substantially in favor of the wide fire-box placed above the frame, presenting a number of plans and suggesting some improvements in boiler construction, and also suggesting that the subject be continued for another year, in view of the fact that a large number of locomotives with fire-boxes above the frame are now being put in use or will shortly be, and that it will be desirable to collect the experience obtained with these.

The Committee on the Efficiency of the Link as Compared with other Valve Motions—Messrs. James M. Boon, David Clarke, H. Tandy and John A. Coleman—presented a report containing references to the Morton gear, the Joy gear, the Walschaert gear, the Stevens valve motion, the Wolfe gear, and to several others which have been tried in past years. The committee regret having no report of the performance of the Strong valve gear. While admiting the deficiencies of the link motion, they claim for it the advantages of standing rough usage. Their conclusion is summed up in effect in the following paragraphs:

"It frequently happens that the poor results obtained from a locomotive are charged to the valve motion, when the cause may be found in contracted steam passage pipes, leaky valves or pistons, steam wire drawn through the throttle, and back pressure, caused by contracted exhaust nozzles. It is surprising what a change will be made in the back pressure line of an indicator card by slightly increasing or diminishing the opening in the exhaust nozzle.

"In conclusion, your Committee are of the opinion that there has not been brought to their notice a valve motion more efficient for all-around work and general utility than a well-designed link with large bearing surfaces—assisted

in its work by steam passages and pipes of generous dimensions—free from sharp turns and bends—giving the link plenty and hot steam to distribute, and, most important of all, not crippled at the very end by a contracted exhaust nozzle."

COMPOUND LOCOMOTIVES.

The Committee on Compound Locomotives—Messrs. J. Davis Barnett, John Player, H. D. Garrett and F. W. Dean—presented a report, the substance of which is given below. The subject is divided by the Committee into several heads:

I. *Is compounding of any value without increase of boiler pressure?*

On this point the Committee is inclined to believe that a considerable gain may be effected by compounding at the present usual working pressures; at the same time believing that there are wide possibilities with increased pressures and temperatures.

II. *What gains have followed compounding?*

1. It has achieved a saving in the fuel burnt averaging 18 per cent. at reasonable boiler pressures, with encouraging possibilities of further improvement in pressure and in fuel and water economy.

2. It has lessened the amount of water (dead weight) to be hauled, so that

3. The tender and its load are materially reduced in weight.

4. It has increased the possibilities of speed far beyond 60 miles per hour, without unduly straining the motion, frames, axles, or axle boxes of the engine.

5. It has increased the haulage power at full speed, or, in other words, has increased the continuous H. P. developed per given weight of engine and boiler.

6. In some classes it has increased the starting power.

7. It has materially lessened the slide-valve friction per H. P. developed.

8. It has equalized or distributed the turning force on the crank-pin over a longer portion of its path, which of course tends to lengthen the repair life of the engine.

9. In the two-cylinder type it has decreased the oil consumption, and has even done so in the Woolfe four-cylinder engine.

10. Its smoother and steadier draft on the fire is favorable to the combustion of all kinds of soft coal; and the sparks thrown being smaller and less in number, it lessens the risk to property from destruction by fire.

11. These advantages and economies are gained without having to *improve* the man handling the engine, less being left to his discretion (or careless indifference) than in the simple engine.

12. Valve motion, of every locomotive type, can be used in its best working and most effective position.

13. A wider elasticity in locomotive design is permitted, as, if desired, side rods can be dispensed with, or articulated engines of 100 tons weight, with independent trucks, used for sharp curves on mountain service, as suggested by Mallet and Brunner. One such engine of 80 long tons is now under construction.

III. *What losses are said to have followed compounding?*

1. In some particular types, as actually proportioned, a loss in starting power of from 15 to 20 per cent. However, loss of power in starting cannot be said to be a defect in the principle of compounding.

2. An increase in the number of parts. They are few and plain in the two-cylinder engine, entailing little outlay in first cost or in repair.

3. A possible, but, this Committee thinks, not probable, increase in the cost of repairs to the boiler per pound of fuel burnt, if higher pressures are used. Positive information on this point is difficult to obtain.

4. An increased cost of repairs to the engine per mile run. This item is not yet large enough to be measurable, after three years' continuous service in the plainer forms of the two-cylinder compounds.

5. A larger percentage of failures on the road due to greater complication and size of parts.

6. Increased reciprocating weights on one side, either not balanced, and so increasing the deflection of the engine, or, if approximately balanced, the balance weight doing injury to the road-bed, etc. The two last sections seem to be pure suppositions, which, after search, we find no evidence to sustain.

7. Want of variability or adaptability to wide extremes in speed, and to amount of work to be performed; so that a large compound does not work as cheaply when hauling light loads, or running without load, as a simple engine does.

It is not proved that a compound, working properly throttled—that is, with steam wire-drawn—may not have actually, as she theoretically has, a wide and economical adaptability. So that if the compound, like any other motor, be not as economical when exerting low power as when exerting full power, it probably will use less steam than the simple engine of same weight, working under similar conditions of light haulage duty.

However, the one thing certain about American conditions is that no large portion of our motive power does run lightly loaded, and until we have a wider experimental experience, it is not recommended that all locomotives, doing branch and local light service, be built compound.

IV. *What is the increased cost per engine?*

Von Borries makes the cost of a compound engine of his design from 2 to 5 per cent. cheaper than an ordinary engine of the same power. Where the same boiler is kept a compound engine would be 2 or 3 per cent. heavier and 4 or 5 per cent. more costly, without making allowances for any gain in power. Others estimate the cost of the two-cylinder compound as differing from an ordinary engine chiefly by the cost of the intercepting valve and receiver. The cost of the three-cylinder compound would be from $1,000 to $1,250 greater than that of the ordinary engine, on account of the increased number of parts.

The cost of changing simple to two-cylinder compound engines need not exceed $250 to $300 each, if the expense of drawings, patterns and templets be divided over a series of engines. The additional cost of building a two-cylinder engine, with receiver, etc., as used by the Michigan Central Railroad, or the ingenious form of four-cylinder engine, as used by the Baltimore & Ohio Railroad, need be little, if anything, over $200 (excluding royalties), or say from 2 to 2½ per cent. increase on the cost of a simple engine.

V. *Does the saving more than balance the increased first cost?*

If, for convenience, the fuel saving be taken at 17 per cent., or $\frac{1}{6}$, and the gross consumption at 900 tons per year, with coal at $1.50 per ton, the decrease in the annual fuel bill is but $225—certainly not a wide margin to cover contingencies. If, however, at first only the more powerful engines are compounded, whose consumption averages 1,200 tons per year, and coal, as is common, costs on tender $3 per ton, the saving on fuel is $600, or 2 cents per mile on a mileage of 30,000 per annum. As this amount would cover not only reasonable interest on first cost, but also allow for about 33 per cent. increase in total expenditure for motive power, repairs and renewals, the saving is certainly enough to permit a possible, but, we think, not a probable, largely increased cost of engine repairs, and yet have a margin of saving on the final balance sheet to the credit of the compound.

VI. *What are "American Conditions" for locomotive service? Can the compound engine meet them?*

We have given this section a large amount of attention, because it has so often been said that the compound must, to be successful on this continent, be adapted to suit American conditions, and your Committee naturally were desirous of fully understanding these conditions. They have not been specified by those making the assertion; and we must reluctantly confess to having failed to identify, much less define them, so that after a long, unsatisfactory chase, they appear to us to be somewhat mythical. If any member can, and will, specify them, he will confer a favor, at least upon the Committee, if not upon the Association.

If an American condition be large starting power, then the Malett two-cylinder and all four-cylinder engines easily have cylinder power in excess of their adhesive weight. If American conditions be ability to do satisfactory work on a second-rate or third-rate road-bed, or simplicity of con-

struction, or easy accessibility of parts, then these conditions are met by any two-cylinder engine, or by the Baltimore & Ohio four-cylinder engine.

Apparently neither climate nor men are factors in this equation, as compounds are a success in the hands of ordinary enginemen in partially civilized countries; and in hot climates, as well as in Russia, under conditions of low temperature and snow as trying as those ordinarily met with inside of 51°, the present northern limit of our railroad belt.

VII. *Is it an essential defect of compound locomotives that they must be short of starting power?*

Certainly not! The starting power of the Malett type is at least equal to that of a simple engine of the same weight, and its cylinder power can easily be made to exceed it, by allowing more than half boiler pressure in the large cylinder for the first few revolutions. In the Von Borries, Worsdell, Pitkin and other two-cylinder types, and the Lepage three-cylinder engine, their starting power (as Professor Woods has graphically illustrated), at 170 lbs., may be greater than that of a simple engine at 150 lbs., having cylinders of the same size as the high pressure *during the first half revolution*, but that after this the power (at low speed) of the compound diminishes to 80 or 85 per cent. of that of the simple engine. This conclusion is modified and improved by the knowledge that all two-cylinder engines originally designed as compounds have, or should have, their small cylinder larger than the cylinder of the simple engine of corresponding weight or duty.

It is possible, with the Lindner or equivalent form of starting valve—and a painstaking engineman—to get about 90 per cent. of the starting power of a corresponding simple engine. The Webb type of three-cylinder engine (except with the low-pressure crank dead on center) has cylinder power enough to slip both pairs of wheels, and no higher starting power is desirable. What may be called the opposite form of three-cylinder engine (the Sauvage type), with cylinders of approximately the same diameter as used on the Northern Railroad of France, has ample starting power, because the full boiler pressure is admitted direct to the two low-pressure cylinders. In fact, if desired, the locomotive can be continuously so worked—that is, as a simple engine. Tandem and other forms of four-cylinder engines are not wanting in starting power. The Baltimore & Ohio engine in starting, with a gear as simple as the water-tap gear, puts the small piston practically into equilibrium, and thus admits high-pressure steam to the large cylinder.

A mean effective pressure of 90 lbs. in a simple 18 × 24-in. engine will start a train of 13 coaches on a level in a lively fashion, and a compound can easily give the equivalent of that total pressure without being over-cylindered.

Going back to the two-cylinder style of engine, with automatic intercepting valve and limited size of cylinder, it would seem as if all of them were capable of getting into motion the load they were designed to haul at full speed, so that their limitations are that they do not get away quite as smartly, quite as noisily, or with the same tearing effort on fire and fire-box as do certain simple engines that waste both fuel and steam in starting. The comparative difference, in time or distance, required by this class of compound to attain maximum speed, has not yet been shown by experiment, but is probably less than is generally supposed.

Mr. Urquhart, desiring to settle the question of the tractive power of simple engines altered to compound, with one cylinder unchanged and with boiler pressure unchanged, carried out tests, using both indicator and dynamometer; and he reports that at a speed of 10 miles per hour the compound passenger engine suffered the following diminution: In first notch, 42 per cent.; in second notch, 28 per cent.; in third notch, 17 per cent.; in fourth notch, 7 per cent.; and in fifth notch, or full gear, 5 per cent. And a similar test of the freight compound showed, in the first notch, 27 per cent. loss; and in the fourth notch, or full gear, 5 per cent. He goes on to say that, for all practical purposes, in full gear a 5 per cent. difference at this speed may be neglected.

VIII. *General statements and questions.*

A recent press notice credits Mr. Webb with an attempt to reduce first cost by throwing away the valve gear for the low-pressure cylinder, and using in its place a single loose reversing eccentric—in other words, with an attempt to use an invariable cut-off for the large cylinder. And such practice is not unreasonable, if it from the first be acknowledged that the compound is designed for doing a maximum specific duty with high economy, and, therefore, the valve gear cannot be, and is not, arranged for a wide variability of service.

This intention in design most clearly marks all those engines using but one valve, or one valve stem, to distribute the steam to both high and low-pressure cylinders; such, for instance, as the Vauclain piston valve, the Woolfe hollow D-valve, and the Dunbar single valve stem. In the two first mentioned most ingenious valves, the release of the high-pressure cylinder must be at the same moment as the admission to the low-pressure, or it is no actual release; and the cut-off in the low-pressure cylinder marks the exact point when compression in the high-pressure cylinder commences, there being no appreciable receiver capacity in the valves themselves, large as the passages through them have to be. There is, then, it is clear, little elasticity of adjustment in such valves and gears. The cut-off being early in the small cylinder, it must be early in the large, and as a result the compression in the small cylinder is enormous. Thus the conclusion is again brought home to us that the control of the compound, when small horse power is to be developed, must be chiefly through the throttle wire-drawing the steam, and thus reducing the initial pressure.

Putting emphasis on this truth will not frighten those who are familiar with the fact that wire-drawing is common to-day with our best enginemen. And it may here be noted that the *imperative necessity* for this so-called crude practice is the full explanation for the slight use in modern locomotives of screw and other finely divided reversing gears. This statement opens up the whole matter of cylinder condensation, but it is too large a matter to be properly treated in this report.

However, such modern experimenters as Westinghouse, Kennedy, etc., prove that wire-drawing the admission into cylinders of large surface and small volume is more economical than valve cut-offs at less than 50 per cent. of the stroke.

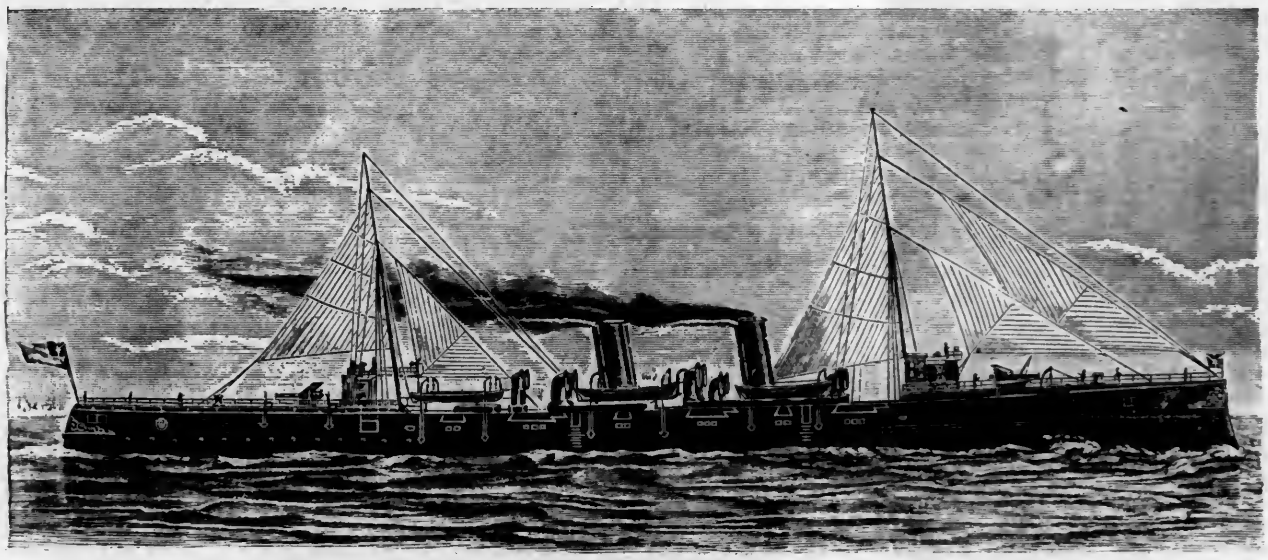
There are some constructive details and peculiarities about compounds that may deserve special mention. For instance, it is judicious to put safety or relief valves on the low-pressure chest or cylinder, but they should be so located or guarded that in case they came into action, they should not smother the engineman with steam, and obscure his vision. All types do not require water-taps on both cylinders, but most receivers should be so drained. If an intercepting valve is used a reducing valve is not required, and if an intercepting valve is not used, there must be a valve to give independent exhaust direct to the atmosphere from the high-pressure cylinder. The weight of evidence, so far, is in favor of the use of an intermediate receiver. Such a device effectually isolates the cylinders, so that each retains its distinctive temperature. The general practice of drying the intermediate steam by putting the receiver in the smoke-box has much to recommend it. Copper pipes, set close to the curve of the smoke-box, are not cumbersome or much in the way; and if it be desired that the feed-water also be heated in the smoke-box, the large receiver pipes need not interfere with the details of such an arrangement. Receiver capacity cannot, under our limiting conditions, be too large. It should never be less than $1\frac{1}{2}$ times the volume of the high-pressure cylinder, and 2 or more volumes are desirable; because, with a liberal receiver, the steam supply to the low-pressure cylinder is more uniform in pressure and amount, the reheating or drying of the steam is more thoroughly done, and the drop in pressure between high-pressure final and low-pressure initial is less detrimental to steam economy.

If one side of a compound should break down, the other side can be run as a single cylinder engine, if the failure is not due to a total collapse of the cylinder on the side to be blocked. And in a tandem, as in a simple engine, the failure on one side may be a total collapse, without its interfering with the use of the other side as a single engine.

THE LATEST ENGLISH CRUISER.

THE accompanying illustration, from *Industries*, shows the cruiser *Latona*, recently launched from the works of the Naval Construction & Armament Company, Barrow-in-Furness, England. This ship is the first of 29 cruisers of a new class, the construction of which was authorized by Parliament last year, 12 of them to be built in navy yards and 19 by contract.

The dimensions of the *Latona* are: Length, 300 ft.; beam, 43 ft.; depth of hold, 22 ft. 9 in.; mean draft, 16 ft. 6 in.; displacement, 3,400 tons. The hull throughout is built of steel, the stern-post being of cast steel. The ship is not armored, but has a protective deck of steel, arched in form, the crown being 1 ft. above the water-line at the center and sloping down to a point about 4 ft. below the load-line at the sides. This deck is 1 in. thick on the crown and 2 in. on the slope and covers the engine and boilers, the steering gear and the magazines. The upper part of the engines, however, projects above this deck, and is covered by a belt of 5 in. steel armor with 7 in. teak backing.



THE NEW CRUISER "LATONA," FOR THE BRITISH NAVY.

The *Latona* is divided into numerous water-tight compartments, and has a complete double bottom. The arrangement of the coal bunkers is such as to afford additional protection to the machinery. There are two magazines forward and aft of the machinery compartments. A conning-tower of steel is placed on the after end of the forecastle, and is so arranged that all the workings of the ship can be directed from it.

The armament will consist of two 6-in. breech-loading rifles on pivot mounts, one on the forecastle and one on the poop; six 4.7-in. rapid-fire guns, three on each broadside; eight 6-pounder rapid-fire guns, four on each broadside; one 3-pounder Hotchkiss and 4 Nordenfelt machine guns mounted on deck. In addition to the guns the ship has four torpedo tubes, one forward, one aft and one on each broadside.

The ship has two screws, each driven by a direct-acting, vertical, triple-expansion engine with cylinders 33½ in., 49 in. and 74 in. in diameter and 36 in. stroke. Six engines are expected to develop 9,000 H.P. under forced draft. The forced draft will be on the closed stokehold system, each stokehold being fitted with two powerful blowers driven by independent engines. The ship is also fully supplied with pumps of different kinds, with ventilation for the quarters, and with a complete electric-light plant, including powerful search lights.

The *Latona* has two pole masts, with a light fore-and-aft rig. The full complement will include 252 officers and men.

THE PROPOSED JUNGFRAU RAILROAD.

ONE of the most remarkable mountain lines in existence will be the railroad up the Jungfrau in Switzerland, if built on the plans proposed by Mr. Trautweiler. A description of his plan is given below, condensed from the *Wochenschrift* of the Austrian Engineers' & Architects' Union.

The line is to start from a point near Lauterbrunnen, at an elevation of 2,850 ft. above the sea; it will be 4.29 miles long, extending to a point 100 ft. below the summit, at an elevation of 10,690 ft. above the starting-point.

It will be entirely in tunnel, averaging 50 ft. below the surface, and will be divided into four sections. The first and steepest, up the west face of the mountain, will be about 4,500 ft. long, with a grade of 98 per cent. The second section will be 6,000 ft. long, with a grade of 48 per cent.; the third, 6,150 ft. long, with a grade of 67 per cent.; the fourth, 4,600 ft. long, with a grade of 33 per cent.

The tunnels are to be 8 ft. 10 in. wide in the clear and 9 ft. 6 in. high, with flat roof and cut stone lining about 8 in. thick. The line will be single track, 1 m. (3.28 ft.) gauge, and a rack-rail will be laid in the center on which the automatic brakes will work.

The cars will have three compartments, each with seats for six persons; they will be about 7 ft. 3 in. wide. The cars will be lighted by electricity.

The stations, three in number besides the terminals, will be cut out of the rock and arched over; each will have room for about 50 persons, and will be provided with a buffet. From the stations inclined passages, from 60 to 300 ft. long, will extend to the surface, so that passengers who wish to do so can stop at any of them and go to the surface to enjoy the view. These passages will be provided with double doors, to exclude drafts.

The road will be a cable line, the cable being worked from a drum at the top. This drum will be driven by compressed air, which is adopted because, as air must be pumped into the tunnels during their excavation on account of the workmen, and continued after the line is opened, there will be economy in this arrangement. The compressors will be about 1½ miles distant from the starting-point of the line, and the air will be conveyed in wrought-iron pipes. The cost of the project is given at $1,120,000, and time of completing the line, five years; and the returns are based on an assumed passenger traffic of 8,000 per annum, at a cost for the round trip of $13.

As might have been expected, strong objections to this undertaking were soon made by physicians, meteorologists, and also by the Swiss Alpine Club, and these objections may be classified as follows:

The tunnels in winter—and even in unfavorable summers—will be full of snow and ice. The water trickling through into the tunnels will freeze, and on thawing in the spring season will work mischief. The cold and drafts in the tunnels will be unbearable. The difference of barometric or air pressure during the ascent will produce sickness and dizziness, and there will be a sad want of proper ventilation. No doubt whatever was expressed as regards the practicability of the engineering details of the work, but it was strongly maintained that the line could never pay. Mr. Trautweiler meets all these objections *seriatim*, and states that, as the line will be entirely underground, snow and ice cannot affect it; that the water trickling through will be of the temperature in the tunnel, which, at a depth of 50 ft. below the surface, will never be at freezing-point, and that such an amount of cold is much more favorable for working in than the excessive heat met with, for example, in the St. Gothard tunnel; that the side passages, or ramps, will be closed by double or triple doors, and thus exclude drafts; that the changes of air pressure are not so great or so sudden as in pneumatic foundations, where the workmen are suddenly subjected to a pressure of three or four atmospheres, under which they work for 40 minutes without injury to health, whereas on the railroad the difference of air-pressure between bottom and top of the line is about one-third of an atmosphere, and the traveler has two hours to accommodate himself gradually to the change. As regards ventilation, Mr. Trautweiler has no anxiety whatever, for air will be continually pumped into the tunnels from below, and the longest of these is not one-sixth the length of the Arlberg Tunnel. With reference to the financial results of the undertaking, the author speaks confidently, and states that the position of the Jungfrau is specially favorable for Swiss passenger traffic; for Interlaken is not only approachable by rail from Berne, but, since the opening of the Brünig line, from Lucerne also; and that, as the line from Interlaken to Lauterbrunnen is now being made, the Jungfrau mountain line will be in direct junction with the most attractive and most largely visited parts of Switzerland, and he is of opinion that it will be as much frequented as the Gaisberg is from Salzburg, and the Mendel from Botzen, whatever the weather may be.

INTEROCEANIC COMMUNICATION BY WAY OF THE AMERICAN ISTHMUS.

By Lieutenant Henry H. Barroll, U.S.N.

(*Continued from page* 253.)

XXV.—THE DE LESSEPS PANAMA CANAL.

THIS canal follows the general course of that proposed in 1875 by Commander Lull for a lock canal, but is located nearer the river beds.

The scheme originally involved an open cut, through the isthmus, at a uniform depth of 28 ft. below the low tide levels of the oceans.

A tide-lock is necessary at the Pacific terminus. The total length of the canal, from sea to sea, is 45.5 miles.

The dimensions were as follows: Width at bottom, 72 ft.; width at water surface, 164 ft.; depth, 28 ft.

In the heavy cutting through the dividing ridge, and which is known as the "Culebra Cut," the dimensions were somewhat different, being: Width at bottom, 79 ft.; width at water surface, 85.5 ft.; depth, 29.4 ft.

The estimates for the excavation, etc., of this canal, were made by a committee of nine engineers, as follows:

G. M. Totten,
J. Dirks,
E. Boutan,
W. W. Wright,
V. Dauzats,
Pedro J. Sosa,
Alejandro Ortega,
A. Couvreaux, fils,
Gaston Blanchet.

This committee adopted as the scale of prices to be used in the computation that fixed by the Paris Conference.

The line between Aspinwall and Panama was divided into three sections, and the estimated quantities to be excavated were tabulated as follows:

General Estimate of Quantities.

Section.	Under Water.			Above Water.		
	Earth.	Hard Soil Capable of being Dredged.	Hard Rocks.	Earth.	Rocks of Mean Hardness.	Hard Rocks.
	Cubic Metres.	Cubic Metres.	Cubic Metres.	Cubic Metres.	Cubic Metres.	Cubic Metres.
Atlantic Section.	9,330,000	300,000	3.775,000	23,710,000	825,000	3,060,000
Culebra Section.	....	....	2,634,000	2,167,000	....	23,199,000
Pacific Section.	2,675,000	....	377,000	1,473,000	....	1,475,000
Total....	12,005,000	300,000	6,786,000	27.350,000	825,000	27,734,000

Grand total, 75,000,000 cubic metres.

General Estimate of Cost.

Work.	Quantities.	Rate per Cubic Metre in Francs.	Total Cost in Francs.
1. *Excavations, including sidings:*			
A. Above water.	Cub. m.		
Earth	27,350,000	2.50	68,760,000
Rock, mean hardness....................	825,000	7.00	5,775,000
Rock, hard.............................	27,734,000	12.00	332,808,000
Rock, where pumping is necessary......	6,409,000	18.00	115.362,000
B. Under water and dredging.			
Mud and alluvial soil....	12,005 000	2.50	30,500,000
Hard soil capable of being dredged......	300,000	12.00	3,600,000
Rocks.................................	377,000	35.00	13,195,000
Total excavation....	75,000,000	....	570,000,000
2. *Dam at Gamboa:*			
Length of crest, 1,600 m.; max. height, 40 m..............	....	....	100,000,000
3. *Channels for regulating rivers:*			
Chagres, Obispo and Trinidad rivers. .. .	....	....	75,000,000
4. *Tide-lock:*			
Pacific terminus	....	....	12,000,000
5. *Breakwater:*			
Bay of Limon (Aspinwall)..............	....	....	10,000,000
Total	....	....	767,000,000
Add 10 per cent for contingencies..........	....	....	76,700,000
Total, in francs......................	....	....	843,700,000
Or, at 5 francs to the dollar.....	....	....	$168,740,000

To this had to be added the cost of the concession which had been secured by the agents of the Société Internationale; also the cost of administration, the interest on dormant capital, the stockholders' guaranteed premium dur-

ing the construction of the work, and the amount paid for the purchase of the Panama Railroad.

It is difficult to even estimate the amount that has been spent in this undertaking, owing to the inability to understand the methods which have been pursued by the Canal Company; but the amount will not at present fall far short of $400,000,000.

In its earliest inception the following advantages were claimed for this route; at that time, the intention of its constructors being to build a tide-level canal:

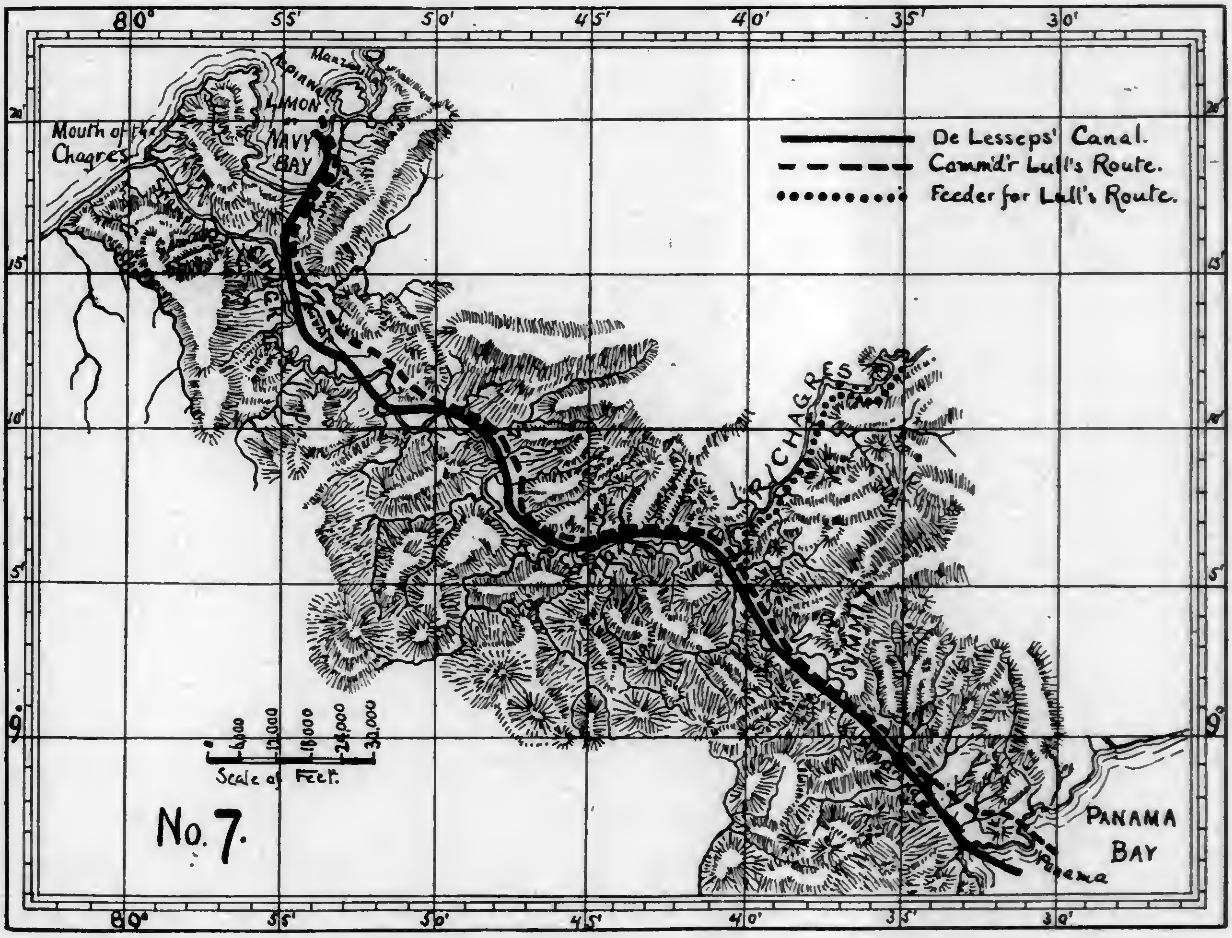
1. That it is the shortest of the practicable routes.
2. That it would cost less than any other canal, offering the same advantages (supposably being a tide-level canal).
3. That it could be constructed in less time than any other canal.
4. That the cost of its maintenance would be less.
5. That it would be more easily preserved from obstructions.

Chagres River into the sea-level canal was therefore claimed to be impracticable.

The Company's scheme to cross the Chagres River at sea-level was also considered to be an unwise measure. It was proposed to lead the canal across that river at sea-level, the waters of the river being led away by an artificial channel. A dam was to be constructed 132 ft. in height, and 5,248 ft. (nearly one mile) in length; the foundation for which could not certainly be relied upon throughout this great length.

The basin thus formed would hold 1,300,000,000 cubic yards of water. This is equal in volume to that of the greatest recorded flood in this region; but in event of two floods occurring in close succession, the basin would overflow into the canal and cause its destruction.

4. The cost of maintenance must necessarily be great, if any attempt is made to control so large a system of artificial drainage.



6. That it has ports at its termini.
7. That it runs through an inhabited country.
8. That there is already a railroad along the entire route of the canal.
9. That a sea-level canal is the only kind that would satisfy the demands of commerce.

The opponents of the scheme claimed:

1. That it was not the shortest practicable route, a sea-level canal across San Blas being 15 miles shorter.
2. It costs more to construct a sea-level canal than one with a few locks; and as it is necessary to have one tidal lock anyhow, this limits as effectually and in the same degree the number of ships that could pass through the canal as would five or six locks.
3. The average rainfall amounts to over 12 ft. annually, and is not distributed evenly throughout the year, but all of the precipitation occurs within a period of 7 months, at most. A rainfall of 6¾ in. in 6 hours has been noted. The consequent heavy floods cause the Chagres River to rise 30 to 40 ft. in a few hours. The original plan contemplated a canal at sea-level; and this would have had to be the ultimate drain of all of this valley. The admitting of the

5. The harbor at Aspinwall is subject to severe "Northers," necessitating expensive breakwaters.

6. The cost of excavation would be greatly increased for a sea-level canal, owing to the great distance necessary to lift materials out of the cut; or to which it would be necessary to carry, before finally depositing them.

Trautwine estimates that when excavation costs 19 cents per cubic yard when deposited within 25 ft., it will cost 57 cents when carried a distance of one mile, and 98 cents when carried two miles. It is of the utmost importance in the case of a sea-level canal that the material excavated be placed at such a distance as to preclude its being washed back into the canal. Finally, a sea-level canal leaves but little chance for the utilizing of the excavated material in fills or embankments.

This objection was, of course, removed when the Panama Canal Company, recognizing the impossibility of continuing their original scheme, commenced the construction of a Lock-canal.

7. The allowance of 10 per cent. for contingencies is never considered by American engineers as sufficient, especially in a country so little known and so little inhab-

ited as Panama. In estimating the cost of a canal by way of Nicaragua, the United States Canal Commissioners rejected the 25 per cent. usually allowed by engineers, and applied 100 per cent. instead. Treating the estimated cost of the Panama Canal, as given by its computers, in this same way the probable cost would amount to $306,800,000.

8. The calms of Panama Bay would cause vexatious and expensive delays to all sailing vessels.

Notwithstanding the clearness with which these objections were placed before the Paris Conference, that body yet decided upon Panama as the proper location for the canal.

The failure of the French Company to pierce the Isthmus at this point, although directed by that able engineer De Lesseps, has been so pronounced that it is well to examine as closely as possible the causes which have led to the same in the hands of one who so successfully connected the Eastern oceans.

The vast strides that have been made in mechanical appliances and inventions since the construction of the Suez Canal should have enabled the excavation of the greater Isthmus-canal with more facility.

The route, as located by M. de Lesseps's engineers, follows substantially that of Commander Lull's survey in 1875. Commander Lull, however, having had a practical acquaintance with this tropical country in the rainy season, had clearly seen the importance of avoiding any attempt to control or divert the course of the Chagres River.

The French engineers, however, instead of attempting to avoid the Chagres problem, attacked it vigorously, laying their canal-route to repeatedly cross this little stream, which in the rainy season becomes equal to one of our largest rivers and sweeps all before it.

In addition to having to contend with the Chagres River, the route lies through morasses teeming with malaria, and through which a canal could only be built by the aid of expensive piling.

The low lands are so unhealthy as to have almost devastated the source from which the Canal Company would draw its labor.

Its failure, then, is due largely to a want of appreciation of the difficulties to be overcome, first, in the climatic conditions ; secondly, in the social status of the laboring classes, and thirdly, in the difficulties to be contended with in the tropical rainy season.

An attempt to control the Chagres River shows what would have been necessary in this water-way.

Commander Lull suggests for the carrying of a canal across this stream a viaduct which shall have its bottom at least 44 ft. above the river's bed. M. de Lesseps, however, proposed to lead the canal through the Chagres valley, protected from the floods which fill that river by a dam at Gamboa, whose crest would be nearly one mile in length and height 132 feet !

Side drains, which in the dry season would have been mere gutters, would require to be river-beds in order to carry off the immense rainfall of the rainy season.

Again, while in the construction of the Suez Canal the engineer had his labor driven to the task of excavating the sands, and no mutiny or objection was tolerated by the stern and absolute Khedive ; in Panama the free Jamaican or Colombian rebels against working knee-deep in malarious slime, except at wages for which *he* fixes the price ; and contractors' bids are always based directly upon the price of labor.

There had been, apparently, no arrangement made for sanitarium or hospital buildings, and when in 1881 ground was first broken for the canal, some 60 engineers and assistants and hundreds of workmen were at once stricken down with malarious, or "Chagres" fever.

This fever finds ready victims in the foreign element, fresh from healthful countries, and unfitted to combat its insidious attacks. It is considered almost as dangerous as yellow fever, and although not contagious, is epidemic and is always present at Panama.

The enervating climate requires at least two or three persons, well overlooked, to perform the work that one man would do in a more bracing climate ; while the overseer himself must at short intervals be renewed, that *his* energy does not deteriorate.

The Chagres River has been made to bear the burden of all of the disaster which has attended this attempt at canal-making. It is really but one of several causes, any of which would have been sufficient to have brought about its failure.

M. de Lesseps, while probably not realizing a dollar of profit from this work, is yet responsible for the immense loss to the French people, who enthusiastically subscribed to the scheme which was headed by his illustrious name.

Even had there been no other possible route, and with the resources of all of the civilized nations of the world, it is doubtful if a canal could have been cut through, after the manner adopted by this company. It certainly could not have been completed at a cost which would have ever allowed the profits to remunerate its stockholders.

(TO BE CONTINUED.)

RAILROAD ACCIDENTS IN THE UNITED STATES.

THE following statement was compiled in the office of the Statistician to the Interstate Commerce Commission for presentation to the National Conference of Railroad Commissioners. The figures are obtained from the returns made to the Commission for the year ending June 30, 1889.

The figures given below make an exhibit of the number killed and injured under the three heads, "Employés," "Passengers" and "Other Persons." They further show the classes of accidents, and the loss of life and injury to persons resulting from each. A summary of these facts is given in the table which follows :

RAILROAD ACCIDENTS
FOR THE YEAR ENDING JUNE 30, 1889.

Kind of Accident.	Employés.		Passengers.		Other Persons.		Total.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
Coupling and uncoupling cars	300	6,757	....	......	......	......	300	6,757
Falling from trains and engines	493	2,011	......	......	......	......	493	2,011
Overhead obstructions	65	296	......	......	......	......	65	296
Collisions	167	820	107	445	37	48	311	1,313
Derailments	125	655	28	389	29	69	182	1,113
Other train accidents	189	1,016	26	247	522	515	737	1,778
At highway crossings	24	45	3	16	410	634	437	695
At stations	70	699	26	295	328	472	424	1,466
Other causes	539	7,729	120	754	2,215	2,397	2,874	10,880
Total	1,972	20,028	310	2,146	3,541	4,135	5,823	26,309

The railroads of the United States carried 472,171,343 passengers during the year covered by this statement, from which it appears that one passenger in every 1,523,133 was killed, and one passenger in every 220,024 was injured. For the year 1888, the rate of casualty in England to passengers from railroad accidents was one passenger in 6,942,336 killed, and one passenger in 527,577 injured. In judging of the above figures, it should be noted that passenger mileage for a given number of tickets sold is much greater in the United States than in England, a fact which mitigates somewhat the severity of judgment upon railroad management in the United States disclosed in the above comparison.

In order to appreciate the above exhibit of casualties to employés of railroads, it is necessary to know the number of employés liable to the various sorts of accidents recorded. The total number of railroad employés in the United States is 704,736, which for the present purpose may be divided into Trainmen, Switchmen, Flagmen and Watchmen, and Other Employés. The number of employés in each class, as also the casualties to each class, is given in the following statement :

CASUALTIES TO EMPLOYÉS,

ASSIGNED TO CLASSES NAMED.

Class of Employés.	Number.	Killed.	Injured.	Per cent of Total.	
				Killed.	Injured.
Trainmen	137,334	1,179	11,301	0.86	8.23
Switchmen, Flagmen and Watchmen	33,344	229	2,155	0.69	6.46
Other employés	517,820	536	6,360	0.10	1.23
Unclassified	16,238	28	214	0.17	1.32
Total	704,736	1,972	20,030	0.28	2.84

The above facts are presented without comment respecting their significance, or respecting their bearing upon the general question of legislation providing for greater safety in the operation of railroads in the United States.

THE DEVELOPMENT OF ARMOR.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

(*Continued from page* 266.)

XIII.—THE TEST OF BATTLE (*continued*).

In July, 1862, the fleets of Flag-Officer Farragut, which had come up the Mississippi, and that of Flag-Officer Davis, were lying above the Vicksburg batteries. The Confederate iron-clad *Arkansas* was lying up the Yazoo. This vessel, it will be remembered, was of the ordinary casemate type and armored with common railroad iron, dovetailed together. On the 15th of the month she came out from her hiding, had a running fight with two gunboats on a reconnoissance up the river, fought her way successfully through both fleets, giving and taking the fire of everything that came in her way, and reached the shelter of the Vicksburg batteries. So mortified was Farragut at this bold dash, that later in the day he ran the batteries again with his entire fleet, with the object of destroying, if possible, the rebel ram. Darkness had fallen before the fleet reached her anchorage, and the movement failed of its object. Most of the projectiles delivered against the iron-clad bounded harmlessly away. Two 11-in. shell got through, however. On the down passage of the fleet a 9-in. shell found its way through. Considering the character of the armor, the number and short range of the projectiles fired against it, one must admit that this was another decided triumph for the iron-clad.

Of the iron-clads in the Union fleet but one seems to figure in the reports—the *Carondelet*—one of the Eads' construction. She had a running fight down the Yazoo, in which she had to present her unarmored stern to the fire of the *Arkansas*, and suffered accordingly. The loss on the fleet was 78 killed, wounded and missing. On the *Arkansas*, 10 killed and 15 wounded. In an engagement with the *Essex* iron-clad a few days later, the latter succeeded in getting a 9-in. shell through her bow armor. Later on her machinery broke down, and she was set on fire to prevent her falling into the hands of the Federals.

The fight in Mobile Bay was in August, 1864, and no better example of the value of armor can be cited. Here a single armored iron-clad—the *Tennessee*—fought for two hours, almost single handed, the entire Federal fleet of three iron-clads and 14 wooden vessels, passing through the fleet, giving and receiving fire at short ranges, and coming out of the fight with armor still in place and not fatally injured. A broadside from the flag-ship of seven 9-in. solid shot at 10 feet distance rattled harmlessly from the 6-in. armor of her side; another broadside from the *Monongahela*, at as many yards, had as little effect. The *Chickasaw*, double-turreted monitor, kept position astern for half an hour, firing 52 solid 11-in. shot at ranges varying from 50 yards to almost touching; the *Manhattan*, another iron-clad, got in six 15-in. shot at short range, and besides nearly every vessel in the fleet had a chance at the Confederate, and yet of all the shower of projectiles hurled at the *Tennessee*, not one got inside the casemate. One of the 15-in. shot from the *Manhattan* broke through the armor-plates and splintered the backing. Under the persistent pounding from the *Chickasaw* most of the plates on the after end of the casemate were loosened, but when the fight was over not one had been detached. Three of her port-shutters had been jammed so that the guns could not be used; her smoke-stack destroyed, and finally her tiller-chains were carried away by a shot, completely disabling her. After enduring the hammering from all sides for 20 minutes longer, her flag was hauled down. Her loss was 2 killed and 10 wounded, among the latter her commander, all resulting from concussion or flying fragments following shot on the port-shutters.

While the iron-clad was passing almost wholly unscathed through the fleet, shot from her guns were crashing through the wooden sides of her antagonists, carrying death and destruction in their path. A very large proportion of the reported loss of 52 killed and 72 wounded may be attributed to the fire of the *Tennessee*, for the losses in passing the forts, except on the *Brooklyn*, were small. The above losses do not include those who went down with the monitor *Tecumseh*.

The monitors were uninjured. It is difficult to understand at this day why the unarmored vessels of the fleet should have hung so closely around the iron-clad, trying to run her down, ramming and engaging at close quarters, when there were three monitors remaining in the fleet, any one of which would have been a fair match for the Confederate. The *Tecumseh*, with her 10-in. turret armor and two 15-in. guns, was at the bottom of the bay, but her consort, the *Manhattan*, with the same armament and armor protection, was at hand, together with the *Chickasaw* and *Winnebago*, from the Mississippi River fleet, carrying each four 11-in. guns and with turret armor of 8½ in.

The short and brilliant career of the *Albemarle* was worthy of the difficulties attending her construction. In her first encounter with the Federal fleet she rammed and sunk the *Southfield*, receiving almost at the muzzle from her and her consort the fire from 100-pounder rifles and 9-in. shell guns. These projectiles broke up harmlessly against her side, and the fragments, coming back upon the decks of the *Miami*, killed her captain and wounded several others of her crew.

A few weeks later a determined effort was made to destroy this troublesome adversary. An officer was sent to the sounds of North Carolina especially charged with this duty. In the struggle that followed, seven Union vessels mounting eight 100-pounder rifles, eighteen 9-in. Dahlgren smooth-bores, and 28 guns of smaller calibers, mostly howitzers, were matched against two 100-pounder rifles behind 4 in. of armor-plate. For nearly three hours the *Albemarle* fought the fleet single handed. First sailing around her, each in turn gave her their broadsides, until, finding this ineffective, they fairly flung themselves upon the iron-clad, crowding in so closely as to prevent effective fire against her. While being rammed by the *Sassacus*, three 100-pounder solid shot were fired into the *Albemarle*, which "were shattered, coming back in fragments upon the deck of the *Sassacus*."

In the fleet one vessel had been disabled by a shot through her boiler and others more or less damaged, with a loss of about 30 killed and wounded, when darkness ended the struggle. The commander of the *Albemarle* reports, "Loss of boats, a riddled smoke-stack, broken plates on the shield, and one gun disabled," but no loss of life and no projectiles inside the turret.

The reports from the commanding officers of four of the vessels engaged show that they threw in this hand-to-hand encounter 60 of the 100-pounder rifle projectiles, principally solid shot, and 173 of the 9-in. smooth-bore projec-

tiles, besides many of smaller caliber. Remembering the hasty manner in which the iron-clad was built and the inferior quality of her material, the showing for the armor-plate is surely a good one.

It has been seen how well the inclined casemate armor of the Western river boats and of the Confederate iron-clads served its purpose. It was in the operations in and about Charleston Harbor and on the Atlantic Coast that the other class of armor-clads—the monitors—were brought to the test of battle. Those of the *Passaic* class saw the most active service. They were single-turreted, with 11-in. turret and 5-in. side armor, in 1-in. plates, and an armament, with some exceptions, of one 11 and one 15-in. Dahlgren.

In the first general attack on the fortifications in Charleston Harbor, April 7, 1863, the iron-clad fleet was represented by seven monitors of the *Passaic* class, the *Keokuk*, a nondescript with thin armor, and the *New Ironsides*, aggregating 32 guns, two-thirds of which were 11-in. Against these were brought an equal number of 8, 9 and 10-in. columbiads, two Brooke and 15 converted rifles—32 and 42-pounders, besides a few mortars and smooth-bore 32 s. Later on, as operations progressed, this number was greatly reduced by the silencing of the guns mounted at Sumter.

Beginning with this general attack on the fortifications in April, and continuing until the fall of Fort Wagner in September, the iron-clad fleet was many times under fire, and often fire of a very trying character. The *Montauk* was 15 times under fire, and on an average each of the monitors was 10 times engaged with the forts. In the attack on Wagner, in July, the *Catskill* alone was struck 60 times. In these encounters the distance varied from 300 to 1,200 yards. During these operations the number of recorded blows upon the armor of the individual iron-clads ran from 36 on that of the *Lehigh* to 214 on the *Montauk*. In the attack of April 7, the *Keokuk* was brought into action between Sumter and Moultrie, and in 30 minutes was struck 90 times, receiving 19 shot at or below the water-line; the turrets were pierced; in short, "the vessel was completely riddled," and sank the following morning.

The behavior of the monitor class of iron-clads was, on the whole, disappointing. After the test of the little *Monitor* in Hampton Roads, it was believed by many that these boats were fully capable of coping with any ordnance mounted along the Southern coast; and from the orders issued for the attack on April 7, it is evident that it was expected in high quarters that the fleet would be able to silence or run by the forts and steam up to the city of Charleston.* The test to which they were subjected was a severe one, and brought out all the weak points in their construction. Without going into the details of the injuries received, it may be said, in general, that the 2-in. deck armor was found to be insufficient, and it was in many instances completely broken through; the manner of securing the side armor by means of blunt bolts was a mistaken one, as the bolts loosened and drew out under severe blows, separating the plates from and sometimes stripping them entirely from the backing; side armor was pierced, and the armor of the turrets in several cases broken through and through, parting the plates in many different places; if struck near the base, the turrets were apt to become jammed, temporarily disabling the vessel. But the greatest defect, or at least the most disastrous, seems to have been the use of through bolts and nuts in setting up the armor on the turrets and pilot-houses. A blow on the outside would send bolt-nuts flying across the turrets like so many projectiles. A very large percentage of the casualties on the fleet during these six months was due to this one cause. The same experience was met with on the casemated iron-clads where this method of fastening armor was resorted to. Especially was this shown on the *Tennessee* in her action with the fleet in Mobile Bay.

Perhaps the most prominent fact brought out in this battle-test of the iron-clads was that of the superiority of the solid over the laminated armor. Side by side with the 5, 7 and 11-in. built-up armor on the sides, pilot-houses and turrets of the monitors, we have the 4½-in. solid armor-plates of the *New Ironsides*. A single glance at the reports will show this superiority. On the one hand we hear of side armor broken, knocked off, or driven into the backing, the plates separating from each other; 11-in. turret armor broken through and pilot-houses almost wrecked. Against this we have the record of six months of the hardest kind of service on the part of the *New Ironsides*. In addition to the pounding she received with the other iron-clads in the various engagements with the forts, on one occasion she fought them single handed for three hours, and only withdrew when her ammunition was exhausted. No material damage was received, and only two men slightly wounded from iron splinters. Neither in this prime test nor in any other of her engagements was she disabled for an hour; nor was the armor seriously injured at any time. Remembering that in the brief engagement of April 7 five out of the seven iron-clads were, for the time being, partially or wholly disabled, the behavior of this vessel is the more to be admired. In one other particular was the *New Ironsides* superior to the monitors. Her armor was secured to its backing by iron wood screws, after the French system. These screws had a hold of about 13 in. in the backing, and gave perfect satisfaction.

(TO BE CONTINUED.)

* Admiral Dupont, in his report of the first attack of the iron-clads, April 7, says: "I had hoped that the endurance of the iron-clads would have enabled them to have borne any weight of fire to which they might have been exposed; but when I found that so large a portion of them were wholly or one-half disabled by less than an hour's engagement, before attempting to remove the obstructions or testing the power of the torpedoes, I was convinced that persistence in the attack would result in the loss of the greater portion of the iron-clad fleet, and in leaving many of them inside the harbor, to fall into the hands of the enemy."

THE HUDSON RIVER TUNNEL.

(From *Industries*.)

SOME time after the failure of the first attempt to tunnel under the Hudson River at New York, the abandoned works were visited, in 1888, by Sir Benjamin Baker, who was furnished with information by the Company's representative as to the nature of the soil, cost and rate of progress of the executed tunnelling, and other details. In the same year a joint report, based upon this information, was presented by Sir John Fowler and Sir Benjamin Baker to the directors of the Company, estimating the time for completion at 18 months, and the cost of finishing the northern and southern tunnels at £180,000 and £250,000 respectively. According to this plan, the two parallel tunnels will be each 5,600 ft. in length under the river and, with their approaches, about three miles in length. The tracks will reach Broadway by easy gradients only 16 ft. below its level at the New York end, and will also rise by easy gradients to the street level at Fifteenth Street, at the Jersey City end. Early in the following year an issue of £300,000 in 6 per cent. mortgage bonds, forming the first part of a total authorized issue of £550,000, was made in London for the purpose of carrying out the scheme, and the contract was shortly afterward let to Messrs. S. Pearson & Son, of Westminster, Mr. Hutton, of New York, being the Engineer, and Messrs. Fowler, Baker and Greathead the Consulting Engineers.

Before passing to a detailed account of the shield now to be employed in the execution of this important enterprise, we may briefly state in general terms that the shield is supported against external pressure by vertical girders. The face of the shield is formed as a cutting edge, and horizontal shelves extending across the shield are similarly armed to pass through the material met. Behind the cutting edges the shield is closed by a diaphragm of plates completely separating it into two compartments. In this diaphragm doors are placed which can be opened to admit the material being excavated, and the pressure of compressed air in the tunnel prevents the admission of water. When harder and water-tight material is traversed the doors are opened, and the excavators attack the face of the heading. When a sufficient quantity of material has

been removed, hydraulic rams attached to the shield advance it by acting against the lining of the tunnel already completed and in position, and a fresh section of lining is at once added. The illustrations which we give in figs. 1, 2 and 3 herewith show the shield in several stages of erection in Sir William Arrol's Dalmarnock Works, near Glasgow. We need not add any detailed description of the views, as they are sufficiently self-explanatory.

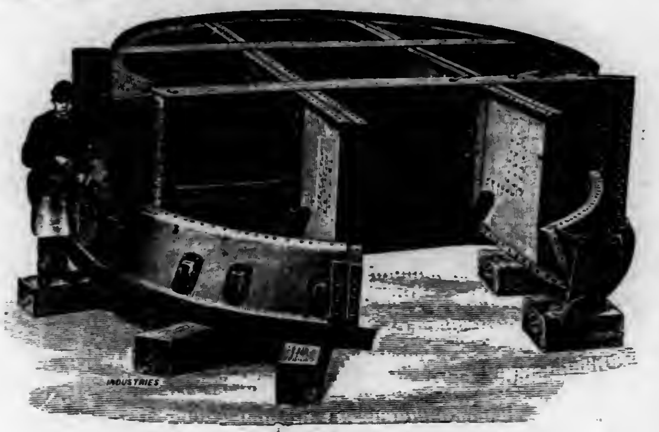


Fig. 1.

We will now turn to details of the shields under consideration. The external diameter is 19 ft. 11 in. by 10 ft. 6 in. from cutting edge to tail of shield. The outer skin is made up of two thicknesses of ⅝-in. steel plates, with internal covers, and packing pieces between the covers, all of a similar thickness. A division of plates ⅝ in. in thickness is placed 5 ft. 8 in. from the cutting edge, and completely divides the shield into two compartments, being pierced by nine doors, of which hereafter. Two horizontal girders between the doors and the cutting edges divide the shield horizontally, the double ½ in. webs of these girders being connected to the door-plates and vertical diaphragms by 6-in. × 6-in. × ¾-in. angles. The two vertical diaphragms, which divide the shield similarly throughout its entire height, are built of 4-in. × 4-in. × ½-in. angles and a ½-in. web. The face of the shield is thus divided by these horizontal and vertical girders into nine cells, access to each of which is gained through a door from the after compartment of the shield. The inner skin of the shield is composed of ½-in. plating, and extends from the plates forming the division of the shield carrying the doors to within 2 ft. 4 in. of the cutting edge, and is separated from the outer skin by a distance of 1 ft. 5 in. Sixteen diaphragms of ½-in. plates 3 ft. 2 in. × 1 ft. 5 in.,

Fig. 2.

with 4-in. × 4-in. × ½-in. angles running completely around on each side, are spaced equidistantly around the shield between the two skins, and arranged to coincide with the attachments of the horizontal and vertical girders already described at their respective junctions with the inner skin. The doors are nine in number, of ⅝-in. plates; seven are square and dished, covering openings ranging from 2 ft. 6 in. × 2 ft. to 2 ft. 3 in. × 1 ft. 9 in., the two remaining ones being triangular and about 2 ft. square; the clips, hinges, brackets, etc., being stout iron forgings, and calling for no special remark. The doors are faced at the bearing surface with india-rubber ¼ in. in thickness. The ⅝-in. plates forming the vertical division of the shield are stiffened by six vertical girders 6½ in. in depth, and each made up of four 3-in. × 3-in. × ½-in. angles, with a top flange plate 6½ in. × ½ in. and a ½-in. web. Sixteen cylinders of cast steel are placed between the two skins equidistantly around the shield. They are 3 ft. 4¼ in. over all, with ex-

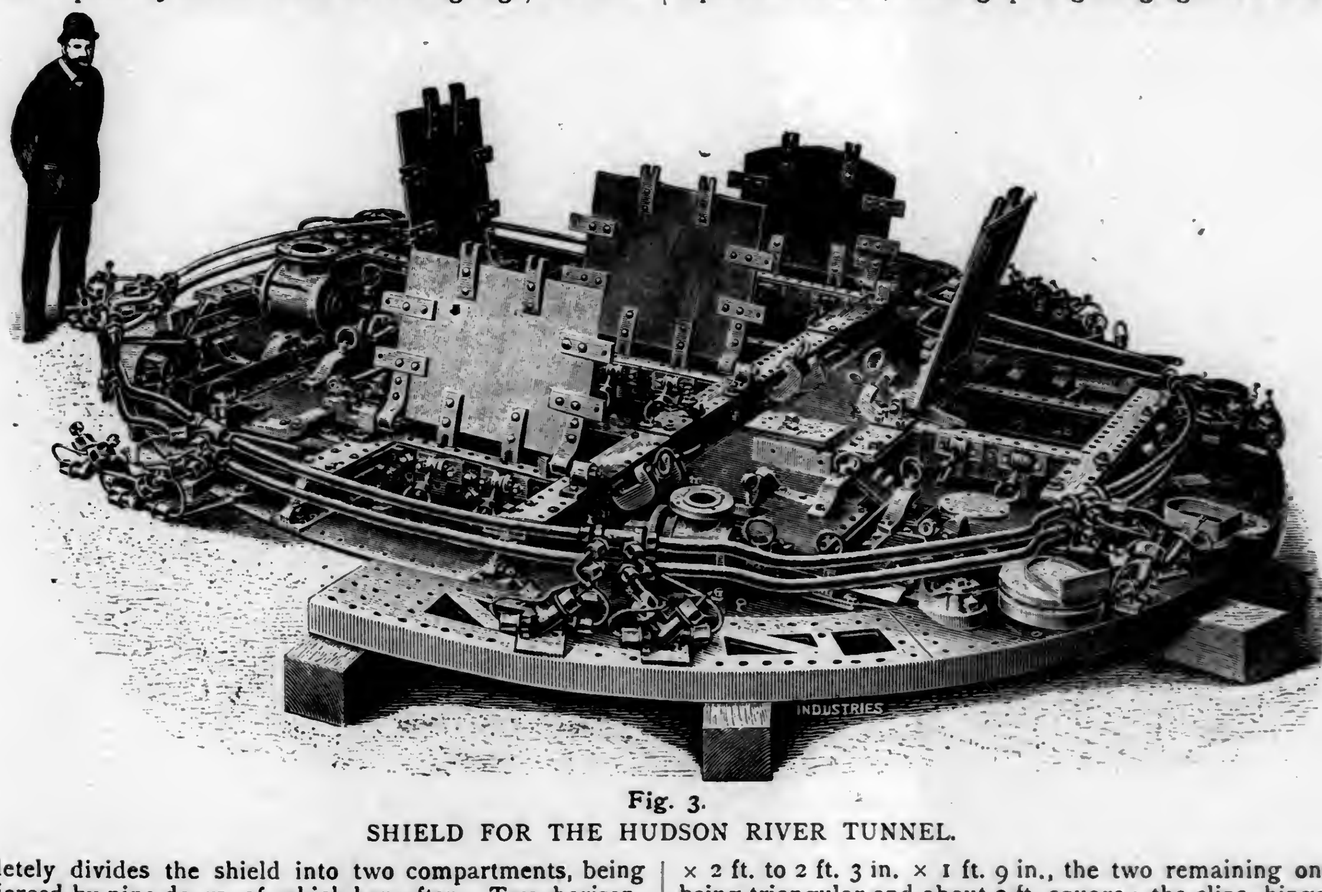
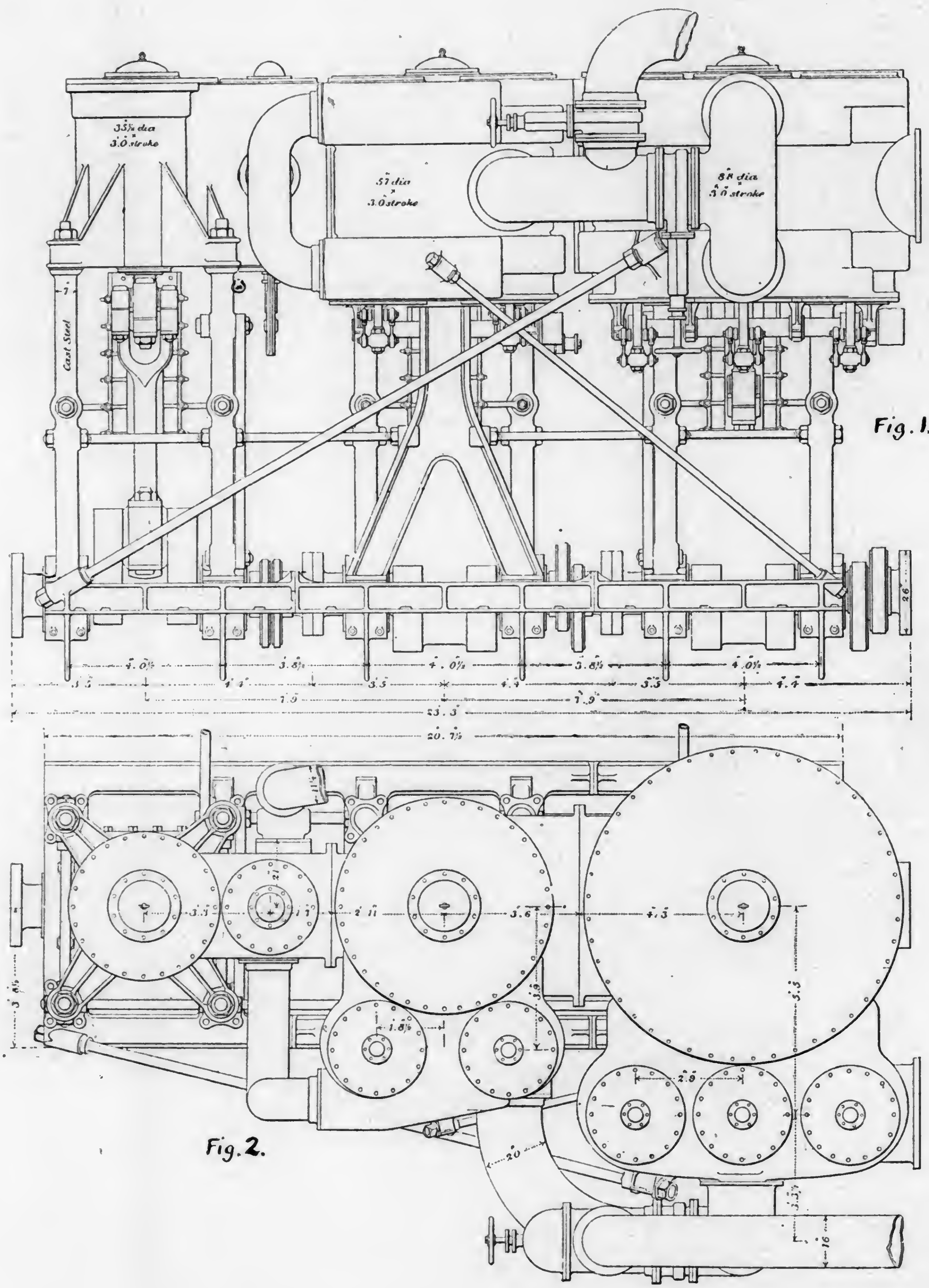


Fig. 3.

SHIELD FOR THE HUDSON RIVER TUNNEL.



TRIPLE EXPANSION ENGINES, ARMORED CRUISER "MAINE."

DESIGNED BY BUREAU OF STEAM ENGINEERING; G. W. MELVILLE, CHIEF OF BUREAU.

ternal and internal diameters $10\frac{3}{4}$ in. and 8 in. respectively. The rams have an internal diameter of $3\frac{1}{2}$ in.

The cylinders and rams were cast by the Steel Company of Scotland at their Newton Works, and prior to despatch were tested to a pressure of 2 tons per square inch, all cocks, tees, valves, etc., being similarly tested to a like pressure. The shields have been made by Messrs. William Arrol & Co., Dalmarnock Iron Works, Baltic Street, Glasgow. The hydraulic segment erecter, which will follow up the shield in the tunnel, placing the cast-iron lining segments in position as the tunnel advances, has been mnufactured by Messrs. Fullerton, Hodgart & Barclay, Vulcan Foundry & Engine Works, Paisley, Scotland.

The contractors' agent is Mr. Moir, recently on the Forth Bridge, and the immediate conduct of the works is in his charge.

THE ENGINES OF THE "MAINE."

THE accompanying illustrations show the engines designed by the Bureau of Steam Navigation for the armored cruiser *Maine*, which is now under construction at the New York Navy Yard. In these illustrations, fig. 1 is an elevation; fig. 2, a plan, and fig. 3, an end view of the engine. Fig. 4 is one-half an end view and one-half a cross-section of one of the boilers, while fig. 5 is a longitudinal section of the same. Fig. 6 is a plan showing the arrangements of the engines in the ship, while figs. 7 and 8 are half cross-sections of the ship showing the position of the engines and of the screw shafts. The description of this engine, as given in the Report of the Bureau, is substantially as follows:

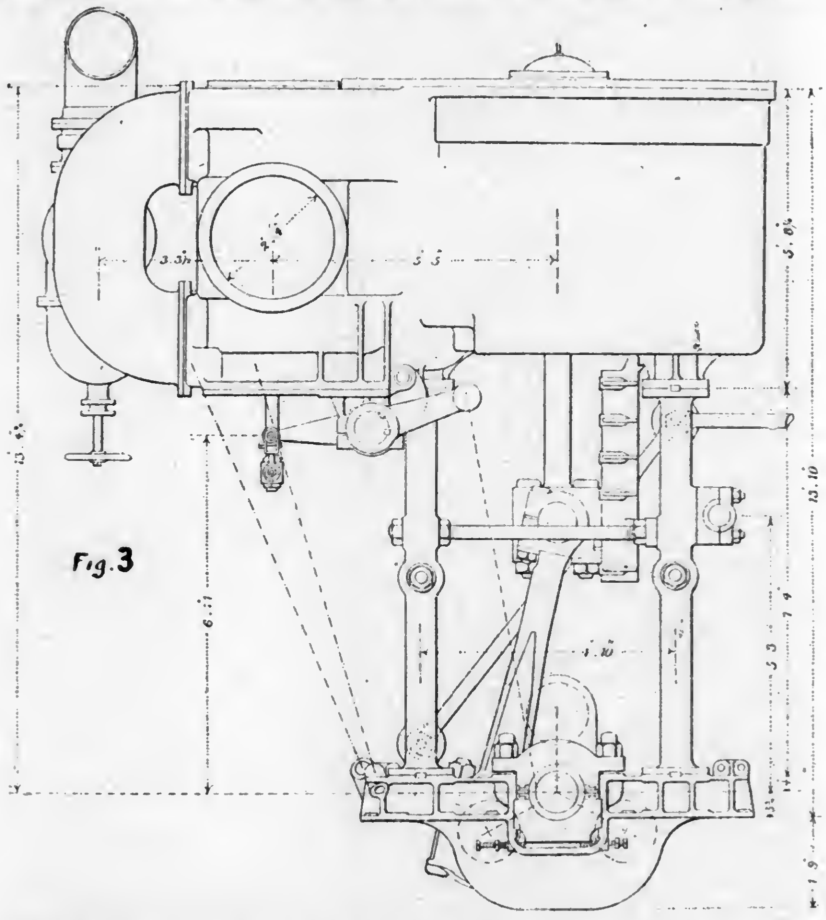


Fig. 3

The *Maine* has two propelling engines, one for each screw, and both alike. Each engine is of the vertical triple-expansion type, placed in a separate water-tight compartment. The cylinders are $35\frac{1}{2}$ in., 57 in. and 88 in. in diameter by 36 in. stroke, and are intended to work at 132 revolutions per minute when at full speed. The calculated power of the main engines with the air and circulating pump engines is 9,000 H.P.

The principle of the interchangeability of parts, now so much used in modern practice, is carried in these engines to the fullest extent. All the cylinders have piston valves of the same size—22 in. in diameter—the high-pressure cylinder having one valve, the intermediate cylinder two, and the low-pressure three valves. For each cylinder the valves are worked from a Stephenson double-bar link. The cylinders have working linings of hard cast iron, and are steam-jacketed.

The high-pressure and the low-pressure cylinders are supported by hollow cast-steel columns, and the intermediate cylinder upon straight columns in front and inverted Y columns at the back. These columns are firmly bolted to the cylinder, to the cast steel bed-plate and to each other. The crank shafts are of forged steel, 13 in. in external diameter at the journals, with axial holes 4 in. in diameter extending through the shafts and crank-pins. The crank-pins are 14 in. in diameter. Each shaft is made in three sections, which are interchangeable. The thrust-shafts are $12\frac{3}{4}$ in. in diameter with 6 in. axial holes, and the propeller shafts are $13\frac{1}{4}$ in. in diameter with $6\frac{1}{2}$ in. and 6 in. axial holes.

A special feature of the propelling engines of this ship is the arrangement for disconnecting the low-pressure cylinders when cruising at low speed. These cylinders are placed forward, and provision is made for easily disconnecting the crank-shaft, thus reducing the engine to a two-cylinder compound which can work up nearly to its full power. This arrangement is expected to give an increased economy over the triple-expansion engines at low pressures. A special exhaust pipe leads from the intermediate cylinder to the condenser for use when the low pressure cylinder is disconnected.

The propellers are to be all of manganese or aluminum bronze, three-bladed and about 15 ft. in diameter.

The condensers are cylindrical in form and of composition plates $\frac{7}{16}$ in. thick. They are 6 ft. $5\frac{1}{2}$ in. internal diameter and the tubes are 8 ft. 4 in. long, the condensing surface being 7,010 sq. ft. Each circulating pump is centrifugal, with a capacity of 8,000 galls. per minute, and is fitted with a bilge connection so that it can be used as a wrecking pump. For each condenser there are two double-acting, horizontal air pumps $17\frac{1}{2}$ in. diameter and 18 in. stroke, driven by a vertical compound engine. The air-pump connecting rods take hold of the same crank-pins as the engine connecting rods. A valve is fitted in each low-pressure exhaust pipe so as to shut off the communication with the condenser and to permit the engine to be used for auxiliary purposes when the main engines are stopped.

Evaporators are fitted for furnishing the steam for the distillers for replenishing the fresh water lost in ordinary running. Connections are fitted from the evaporator to the auxiliary exhaust mains, so that the steam can go direct to the condensers. The distilling plant has a capacity of 5,000 galls. of potable water per day at a temperature of not over 90°, but when the evaporators are used for supplying losses their capacity is greatly increased. Spare coils are provided for the evaporators, so that clean ones can be inserted when it is necessary to remove the scale from those which have been in use.

The *Maine* is provided with eight single-ended boilers of the ordinary return tubular type, 14 ft. 8 in. in diameter and 10 ft. long, designed for a working pressure of 135 lbs. The outer shells are of mild steel $1\frac{1}{32}$ in. thick. Each boiler has three corrugated steel furnaces 42 in. in diameter, and 519 steel tubes $2\frac{1}{4}$ in. in external diameter and 16 ft. 7 in. long. There are in each boiler 401 plain tubes and 118 stay-tubes, the latter being twice the thickness of the ordinary tubes. The total grate surface is 553 sq. ft. and the total heating surface about 16,800 sq. ft.

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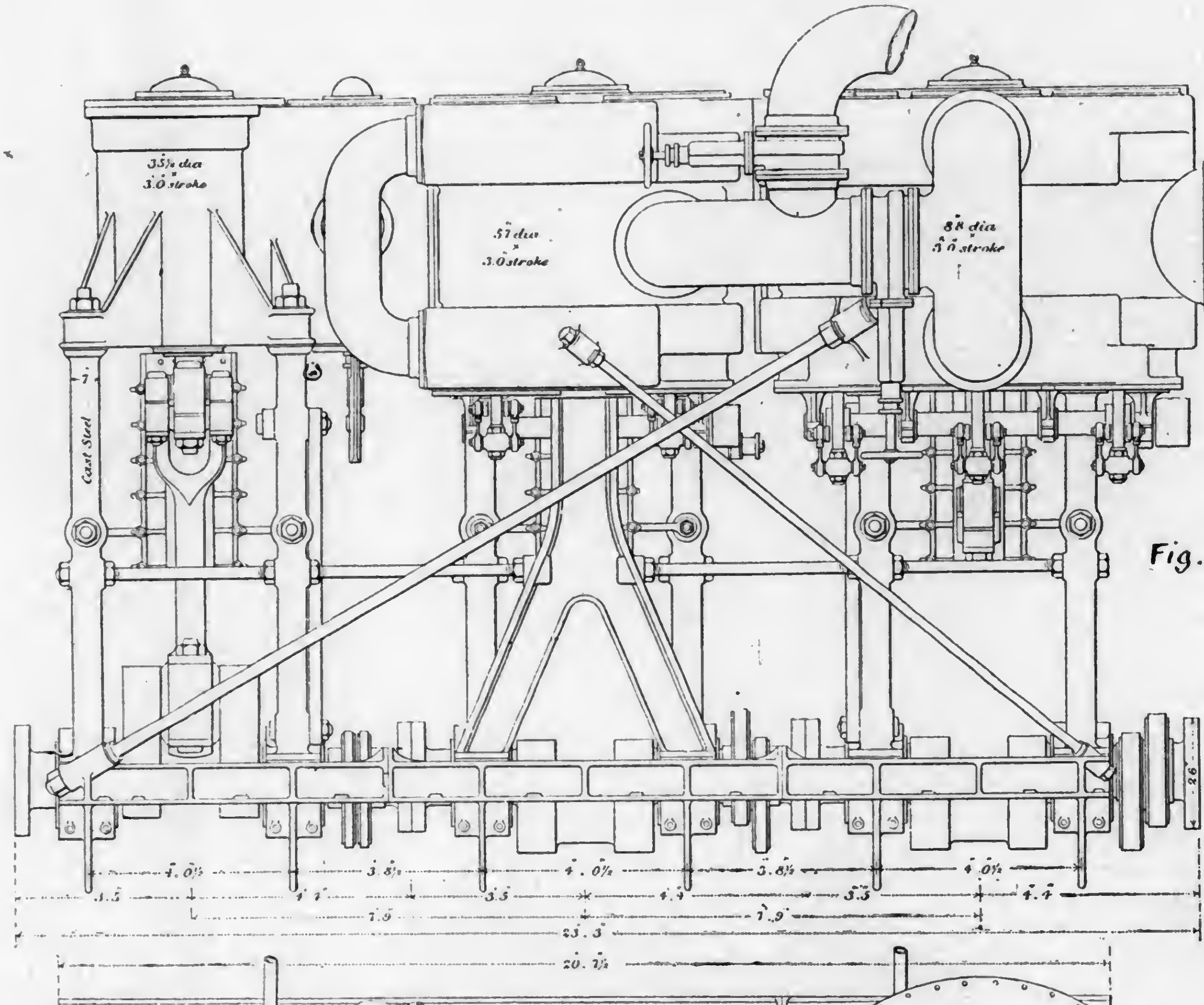

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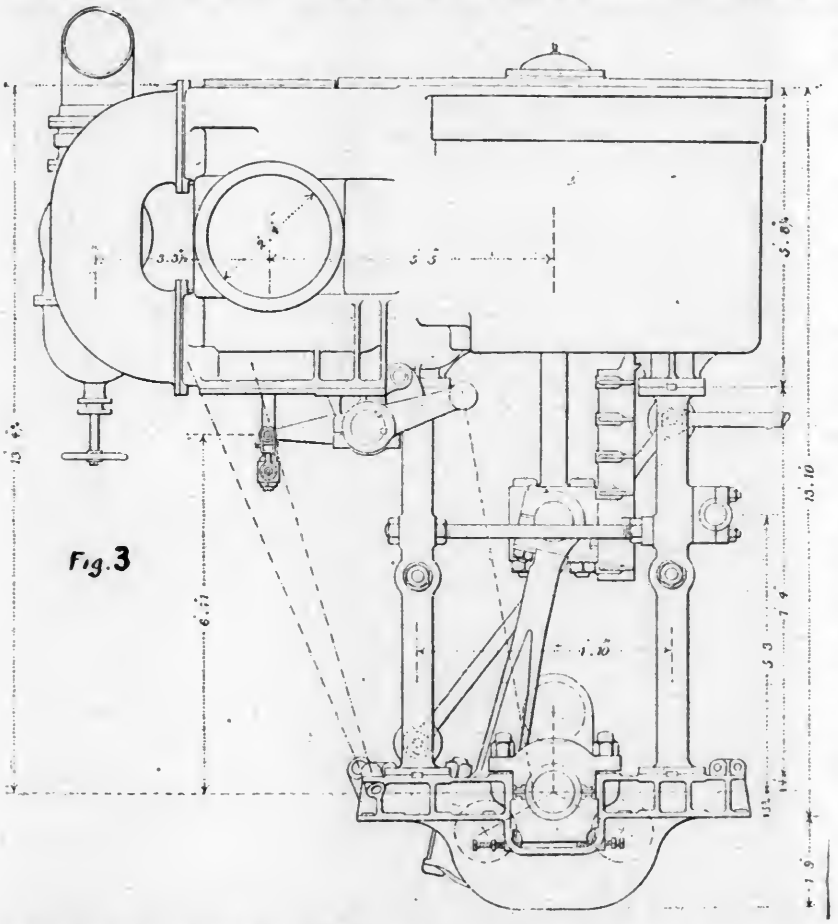

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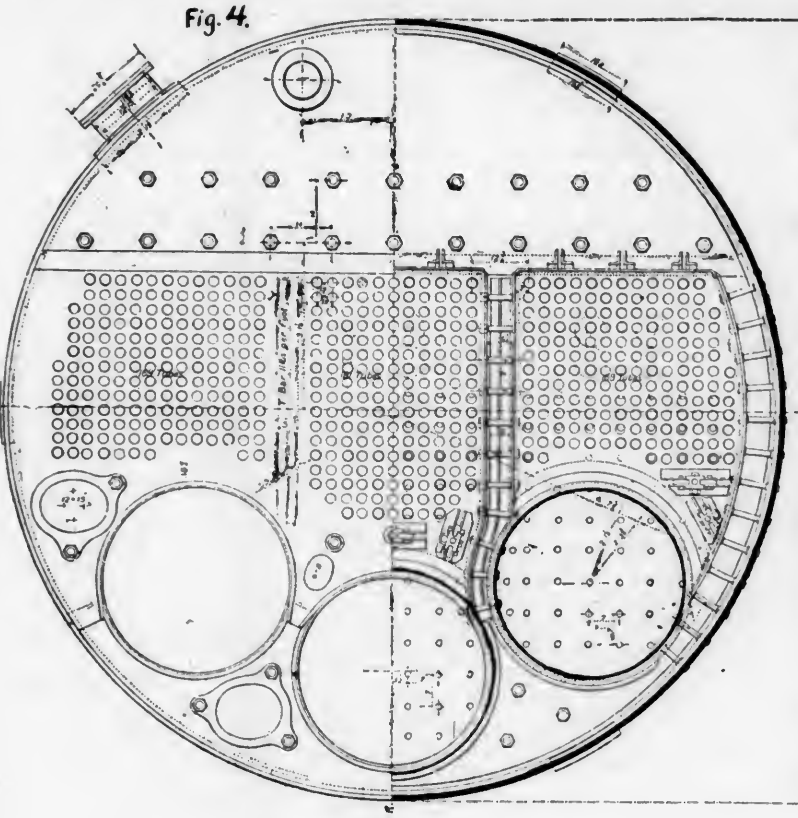


Fig. 5.

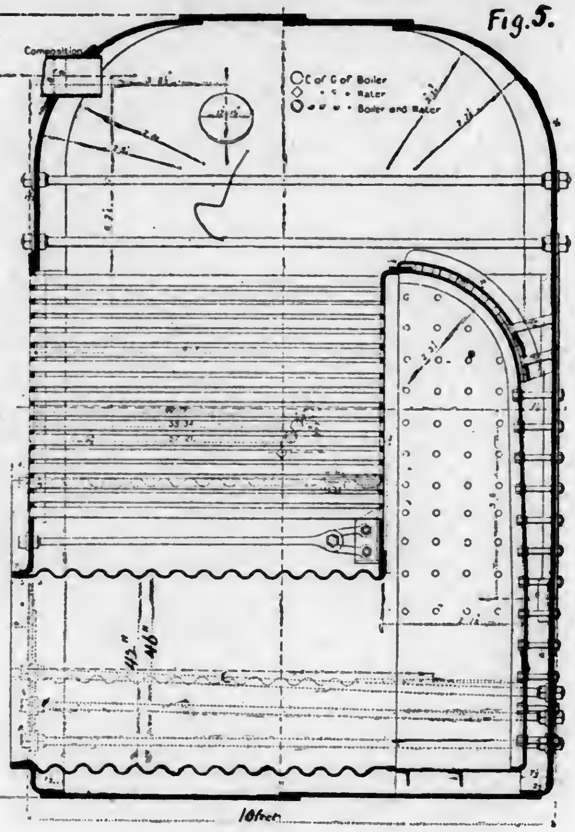


Fig. 8.

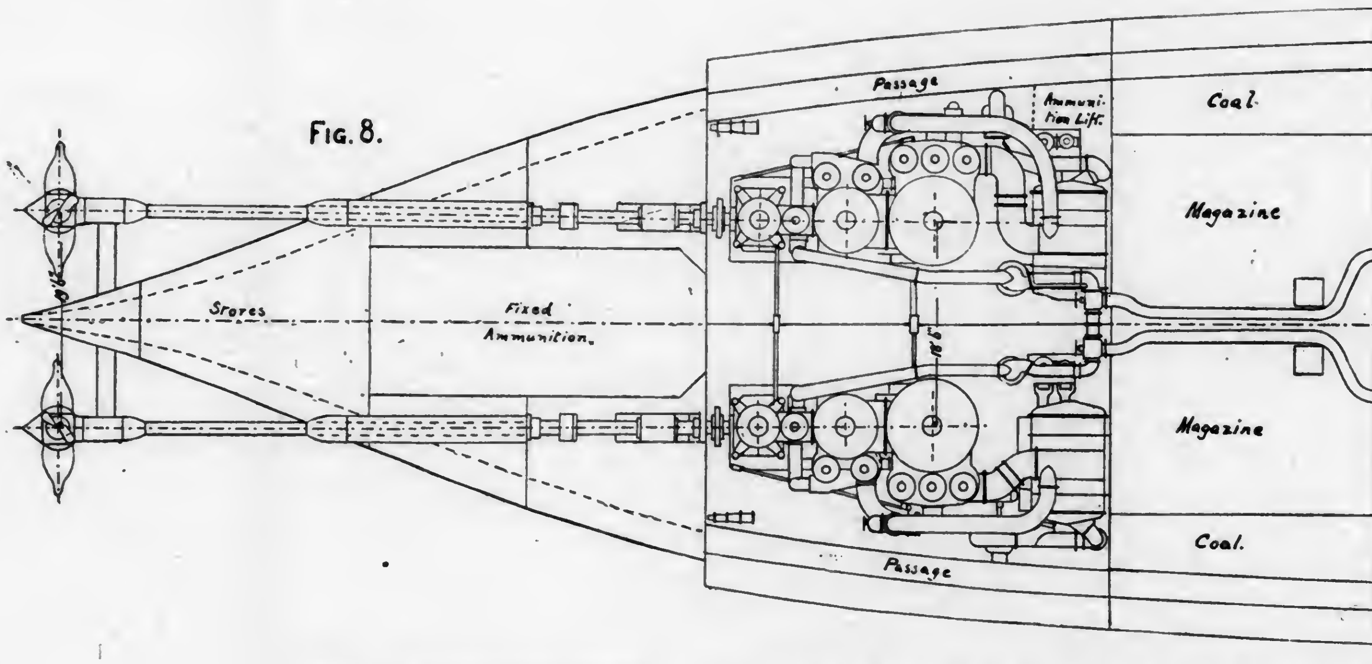


Fig. 6.

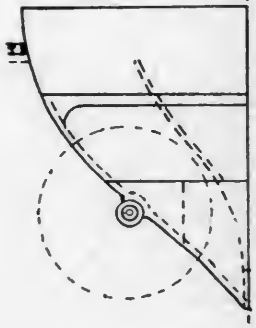
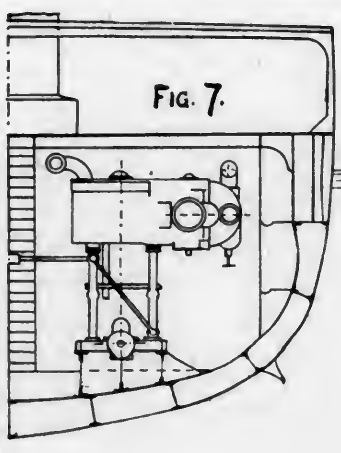


Fig. 7.



partments, four in each, with fore-and-aft fire-rooms. There are two fixed smoke-stacks extending to a height of about 60 ft. above the lower grates. The forced draft is on the closed ash-pit system, the air being led into the ash-pits by ducts under the fire-room floor. The blowers are driven by enclosed three-cylinder engines, and draw the air from the engines and fire-rooms so as to give good ventilation.

The main and auxiliary feed systems are duplicates as to pumps, piping and valves, excepting that the main feed-pump draws water only from the tanks, while the auxiliary pumps can also draw directly from the sea. Provision is made for heating the feed-water.

The auxiliary machinery includes reversing and turning engines, fire, bilge, drainage and flushing pumps, ash-hoists, workshop tools, etc. Besides the steel machinery there is a complete hydraulic plant for operating the turrets and for loading and turning the guns. The working

pressure of this hydraulic plant is 600 lbs. per square inch.

As already noted, the *Maine* is under construction at the New York Navy Yard. The contract for the machinery was awarded to N. F. Palmer, Jr., & Company, of the Quintard Iron Works, New York, for the sum of $735,000. Work is now well advanced on both ship and engines.

LARGE IRRIGATION CANALS.

(Condensed from a paper read before the Denver Society of Civil Engineers, by G. G. Anderson, C.E.)

THE present paper treats chiefly of the practice which has so far obtained in Northern Colorado, where irrigation was first undertaken, and it may be said that in some of the earlier canals but little engineering skill was applied. There have been in that district three distinct periods of ditch building, which may be classed as the individual, the colony or community, and the corporations periods. In the first are included the small ditches made by the pioneer to irrigate his patch of land. In the second class are the efforts to cultivate the mesas by combined effort, as at Greeley and elsewhere, and in the third the large enterprises which have lately sprung up, and which require an amount of capital which can only be furnished by corporations.

In the case of individual effort it may be said that it leads generally to a faulty system, or rather lack of system, and a great waste of water, as can readily be seen; moreover, it cannot be applied at any considerable distance from the sources of supply on account of the expense. As to the canals of the second period, they were often badly made owing to lack of experience; in some cases their faulty location was due to local circumstances, where, in order to obtain water-rights, it was necessary to buy old ditches, and usually their lines were followed. As to the third or corporate period, many mistakes have been due to too great haste in undertaking the enterprise, and to the fact that in many cases the engineers have been compelled to go to work before acquainting themselves properly with the requirements of the district or with its physical conformation.

It may be said as to construction that there are two general varieties of irrigation enterprise: the first being where it is proposed to limit the use of the canal to the cultivation of a distinct area. In this case the highest elevation would be found and the survey carried back to the proposed source of supply. It would then be necessary to decide upon the grade to be given to the canal and the amount of water required for the district, and from these data to calculate the size of the channel needed.

The second case is where, a natural site having been selected for the head-works, it is proposed to construct a canal outward without any limitations save those of economical construction. In this case the size of the channel would of course depend mainly upon the supply of water available.

In either case the engineer should first make himself thoroughly familiar with the physical conformation of the country to be traversed, the character of the soil being carefully examined with special reference to the grade to be adopted, and in this the grade question is found the first vexatious problem in construction. If the grade chosen is too great, erosion of the banks and scoring of the bed will follow, while if the grade is too light, there will be constant trouble from the deposit of silt. So far as possible the grade should be uniform throughout, and if any change is made it should be increased and never decreased, and for the same reason the velocity should be regulated by the cross-sections of the channel to prevent, in both cases, deposit. The general opinion is that a low velocity—from 3 to 5 ft. per second—is best, although some engineers claim that higher speed is preferable, even if it is necessary to protect the channel.

In the older ditches in Colorado grades were generally established too high, being seldom less than 5 ft. per mile, but in later construction the inclination ranges from 6 in. to 3 ft. per mile. More experiment is needed to establish a reliable formula for determining the relation between velocity and capacity of a canal.

The form of the channel is regulated to a great extent by local requirements. Trapezoidal forms are now usually adopted, placed deep when the water has to be carried a certain distance, and shallow where it is to be delivered to adjacent lands along the line of the canal. The larger number of canals are on side-hill work calling for the construction of only one bank on the lower side, and in such cases it is economical to set the channel in a cut sufficient to provide material for the bank.

The beds of large canals are usually provided with a sub-grade—that is, the bottom is sloped from the sides to the center to a depth of from 1 to 3 ft. While the superiority of this form is not generally admitted, the writer's experience is largely in its favor as tending to keep the current in the center of the channel.

The provision of a berme 5 or 6 ft. from the edge of the excavation to the toe of the artificial bank is also advantageous. Large canals are seldom called upon to carry their full capacity for a year or two after their construction, and in such a case the water can be confined by the berme to the excavated part of the channel, giving the artificial bank time to settle and solidify. It is scarcely necessary to say that the construction of flumes should be avoided wherever possible, as they are expensive both to build and to maintain; but they are necessary in certain cases and may sometimes be economical, as where the ground is composed either of very hard or very porous or shattered material. Most flumes in Colorado are of timber; but unfortunately the native lumber of the region is poorly adapted to this class of work, while the sudden changes in the climate renders decay very rapid, so that the average life of the flume does not exceed eight years. It is, however, a financial question, and as long as timber is cheaper than any other material, it will probably continue to be used. The question frequently arises with regard to the construction of flumes, should the grade be altered in any way from that of the canal proper? Experience suggests that if altered it should be increased, even if it is necessary to protect the approach embankments from erosion in order to insure the rapid delivery of water and the avoidance of dead weight on the structure.

Too much importance cannot be attached to the necessity of securing good alignment, and one of the worst features of practice so far has been the use of very sharp curves in large canals. It must be remembered that badly arranged curvature diminishes the delivering capacity of a canal very seriously.

As to the maintenance of canals, the most serious feature is the removal of silt. In some of the canals on the lower districts of the Platte River country, the annual expense under this head is large, and if the canal is poorly constructed it is very apt to have its capacity seriously reduced by deposits. There are various methods which may be employed to prevent deposit. The first is to so arrange the head-works that the water will enter the canal as clear as possible. At the head-works of the High Line Canal, for instance, the dam was built 14 ft. above the bed of the river. Waste-gates on the west side of the river, over 150 ft. from the head-gates of the canal, are 2 ft. below the level of these main gates. The effect of the dam, in the first place, is to form a settling pond, and by always keeping the waste-gates slightly open it is possible to carry a large proportion of the silt into the river below. In addition to this, at the lower or east end of the channel is another set of waste-gates, immediately below which is a check 2 ft. high across the flumes, over which the water has to pass before entering the canal proper. These gates also are always kept open, and with the further safeguard of putting all irrigation outlets level with the bed of the canal, it has so far been kept comparatively free from deposit.

Another method which is frequently adopted in India is to excavate the first half mile with a base sufficiently large to cause a great diminution of velocity. Silt is deposited during floods and excavated when the canal is closed.

It is necessary to provide against damage to head-works by drifting wood, and in streams carrying much of such material dams should be built with a free overflow, affording no obstacle upon which the drift can collect. In Colorado the streams are generally subject to sudden fluctuations, so that the use of planks or similar devices to raise

the water at will is dangerous. Probably the best plan is the use of a floating boom to prevent timber from dragging and lodging against the dam.

In maintaining flumes the great question is the prevention of leakage, and it is generally necessary to overhaul them and caulk the cracks with oakum before opening the canal in the spring. In cases where, from any cause, the flume is left dry in summer, serious leakage will result, causing loss of water at a time when it is precious; to provide against such contingencies the only course seems to be to use double floors laid so as to break joints, and thoroughly coated with tar.

To prevent damage from the erosion of the banks and the scoring of the bed affords a wide scope to the ingenuity of the engineer. Of course much depends upon what material can be obtained most cheaply. In some cases where slag could be readily had it has been found a very excellent material. Mattresses of willow slips in the face of the bank have also been found useful, but diminish the free flow. The scoring of the bed can only be overcome by the use of rock or timber checks.

A formidable difficulty in maintaining a large canal is the making provision for storm water; this is particularly the case with a canal on a side-hill, which intercepts the drainage from higher lands, and here it may be said is one advantage in low velocities and grades, since a large body of water is troublesome enough to handle without increasing its impetuosity by giving it a high velocity. Waste-ways must be provided at the best natural sites, and there must be constant watchfulness. Flumes should be provided with waste-gates sufficient to discharge at will one-half the capacity of the canal, and where natural waterways are crossed by embankments, flumes for waste should be made at either end and sufficiently far from the embankment to prevent waste water from injuring it. The construction of timber waste-ways in the center of embankments is not to be recommended, as it will certainly destroy the embankment. Waste-gates upon flumes are usually constructed on the sides, and it may be found that in such a position they are not adequate for the purpose of withdrawing large bodies of water. The quickest method of emptying a flume is from the bottom, and this plan should be adopted if possible. Automatic gates have been tried, but are generally out of order when wanted.

Damage to flumes by floods in creeks and water-ways crossed by them may often be prevented by careful observation of the locality and by changing direction of the stream.

The cost of maintenance of a large canal will vary with the excellence of the original construction, with the topography of the country and many other considerations. A California estimate is $400 a mile, including all repairs, but in practice in Colorado the amount has varied from $150 to $400 a mile.

In operation a large canal should be arranged in divisions, each under a superintendent or, as he is called in Colorado, a "ditch-rider." The length of these divisions will depend upon the number of outlets and the character of the work, but it should be so regulated that the superintendent can visit over part of his division daily; and he should make a daily report. It is important that the engineer in charge should be informed daily of the quantity of water entering the canal and the quantity attainable from the source of supply.

The question of how best to distribute water over a district is a very important one; while more or less skill has been devoted to the construction of the main canal, the laterals have been left very largely to the cultivator, and to this fact, more than is usually conceived, is attributable a large amount of the trouble and annoyance created over the otherwise sufficiently troublesome question of distribution. To say nothing whatever about the judicious or injudicious construction of the subsidiary channels, though it has as much bearing on the question as the construction of the main canal, while the distribution of water from the main canal is attended by at least some attempt at regulation, it is very rarely indeed that there is any such upon laterals. The absence of such regulation increases a hundredfold all the natural difficulties surrounding proper distribution, and urgent consideration of the question in practical form should be undertaken by the cultivator, whose interests are bound up in it. Very considerable objection has been manifested to the system of distributing water by the acre or the crop, and it is doubtless true that whenever comparisons have been made of the duty of water under these systems and under the distribution by quantity they have been favorable to the latter. It has not been possible, from an operative point of view, to successfully introduce the latter system in Colorado, partly for reasons outlined in the foregoing remarks; and though canal companies have been condemned for stopping the way of this improvement in the economical use of water, it is fairly presumable that they will welcome the adoption of a system so largely to their financial interests, if they can be assured of the reasonable possibility of its introduction, particularly should it tend to lessen the constant friction between the individual consumers and between them collectively and the canal company. At present it does not seem possible to adopt either the horary system or the rotation system in canals. The latter, one may conclude, is capable of successful application only in canals with very large capacities and almost always certain of supply. It is applied in India, where some of the canals carry as high as 5,000 cubic feet per second. With such a supply it is possible to conceive of one canal being supplied with water for one day only in two weeks, and distributing it with good practical results. Under ordinary circumstances in Colorado one day's run of full capacity in a 50-mile canal would barely give any water at the lower end.

The horary system can probably be applied on similar conditions, certainly as regards the supply. In Colorado it may be concluded that the value of water is not yet rated sufficiently high to permit of the successful application of the system.

There is still lacking in Colorado a simple and easily understood method of measurement and a definite unit of measurement. The gauge which was known as the "Max Clarke Gauge," and the Foote system have both been used, but neither of these is adapted for large canals. The method gaining in favor, in spite of some drawbacks, is the sharp-edged weir, the Francis formula being adopted. Where this is used the depth of water on the weir should not exceed one-third of its length; the depth in the chamber before the weir should be at least three times that on the weir, and the tail-water should not be allowed to rise higher than 6 in. under the head of the weir plate. It is not always possible to obtain these conditions, owing to the imperfections of the lateral channels, and there is the further disadvantage of loss of head, preventing the utilization of lands close to the canal.

In Colorado the inch system of measurement of water supplied is enforced by law, but the cubic foot per second, although not generally recognized, is really the correct system. The inch system is practically obsolete, and will be finally displaced.

In regard to the duty of water, it may be said, in the first place, that it is difficult to lay down any rule in regard to it. The same soil will be affected differently in various climates; differing soils will require differing duties in the same climate, and different crops need different quantities of water. The duty of water is also largely affected by local requirements and practices, such as have been already referred to, and being so it cannot be said that the duty in Colorado should be the same as in Spain or India. If the duty of water in one place is five times less than in another, it raises the presumption that the duty is small and might be increased. Probably the smallest duty of water known is in the Valencia plains, where it is at the rate of 35 acres per cubic foot per second, but that is in the rice cultivation. On the same plains in general crops the duty reached 101 acres per cubic foot. In Granada, where water was scarce, it reached 286 acres per cubic foot, and in Elche and Lorca still higher duties were obtained; in the former one cubic foot did duty for 1072 acres, and the latter gave the enormous duty of 2200 acres. In India a duty of 240 acres on the Ganges Canal was obtained, while it reached 250 acres on the Eastern Jumna Canal. In short, the duty obtainable out of water was very much a question of the quantity of water disposable. In the older canals of Colorado, a duty was established of

55½ acres per cubic foot per second. In later enterprises, it has been the effort to reduce it, to give at least 100 acres per cubic foot, and Mr. Maxwell, the State Engineer, is authority for the statement that the duty can be made 320 acres per cubic foot.

The great purpose of an irrigation enterprise is to endeavor to extend the service of the water to the maximum acreage, and in spite of the present low duty of water and the difficulties that have been met in the past few years in the great scarcity of supply, which ought to have been of great service to those willing to benefit by experience in an effort to increase it, it is not too much to hope that a gradual increase of duty will be speedily obtained.

Other questions relating to irrigation—such as sub-irrigation, damages accompanying irrigation and the legislation affecting the whole subject—cannot well be treated in a single paper. The necessity for proper legislation is very great, however, as the risk in enterprises of this kind is sufficiently great without further burden of unjust and oppressive laws, and the law should be put in such shape as to be readily understood by all concerned.

In Colorado, as in most other irrigation countries, the necessity of carrying on works of drainage and irrigation simultaneously is being impressed upon practical men more and more every year. Although it is a rare occurrence when these works are successfully conducted together, it is regrettable to note the large and yearly increasing area of low-lying lands going to waste, and which are, during the irrigation season, stagnant swamps, breeding disease. The frequency of typhoid fever and other epidemics in the fall of the year is doubtless due to this cause, so that, from a sanitary point of view at least, drainage must be speedily undertaken On the other hand, on this matter of drainage the necessity of providing for the storage of water for the lands drained must not be lost sight of. It has been the experience of countries where, during wet seasons, great efforts have been made to carry off the water by drainage, that, in dry seasons, crops have been seriously affected by the lack of proper provision for storage of water.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

VIII. METHOD OF PURCHASING OILS.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page 272.*)

For the sake of completeness in the discussion of lubricants and burning oils, this article will be devoted to the question of how oils are bought, and to a discussion of hot boxes and hot box and lubricating greases.

It was formerly the custom with lubricating and burning oils to buy by measure, and measure was also used in distributing the oils for use in the service. This practice has been largely abandoned, it having been found that weight is not only a much more expeditious way of getting at the results, but also a more accurate one. If oils are bought by measure, with no check on the shipment, the number of gallons being stamped on the barrels by the manufacturer or shipper, there is a very wide chance for practices which are hardly to be recommended. At one time on the Pennsylvania Railroad a number of shipments of oil from a certain party were weighed, and the barrels emptied and the tare taken. On checking up the weights it was found that the barrels were universally from one to two gallons short. Indeed there was enough difference in the amount of oil charged for and the actual amount received to enable the party to bid from half a cent to a cent lower per gallon than those who gave full quantity. In the large amount of oil used by the Pennsylvania Railroad, the loss due to this practice amounted in one month to as much as $250 on one kind of oil, and at one place where the oil is received. This led to a change in practice, and now all oils are bought by weight, which method gives a very quick and efficient way of checking up a shipment, as will be seen by studying the circulars given below. When this practice was inaugurated, a circular was distributed by the Purchasing Department, informing the manufacturers what would be required in future in regard to shipments. This circular is as follows:

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Purchase of Oil by Weight.

From this date, all materials used as lubricants and burning oils will be purchased by weight, and quotations of prices and bills must be by the pound. In quoting prices, cents and hundredths should be used. A separate bill must be rendered for every shipment, however small, even though it be but a portion of the whole order, and the bill must be sent *as soon as possible* after the shipment is made.

Every package containing lubricants and burning oils must be plainly marked with the gross weight and the tare. This applies to oil tank cars as well as to barrels. Parties failing to mark both gross and tare on their packages must accept the Company's weights without question.

Whenever a shipment of any lubricant or burning oil is received at any point, it will be immediately weighed, and where practicable will be at once emptied, and the empty packages weighed. If not practicable to empty all the packages, 5 per cent. of the shipment will be emptied and the tares taken. The tares of the whole shipment will then be adjusted in accordance with the weight of the 5 per cent. If the net weight found from above data is less than the amount charged for in the bill by more than 1 per cent., a deduction will be made from the bill equal to the amount of the deficiency over 1 per cent. This 1 per cent. covers leakages in transit, and the amount which adheres to the barrels in emptying; also, possible slight differences in scales.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of the General Superintendent Motive Power, Altoona, Pa., October 1, 1885.

It took a little time for those who were accustomed to think of the price of oil in gallons to learn to compare prices by the pound, but this difficulty soon disappeared. It will be observed that the circular calls for a bill for each shipment, although the whole order may not be filled. The object of this was to enable the adjustment mentioned at the latter part of the circular to be made as soon as possible after the shipment was received. This method described in the circular, so far as the manufacturers and shippers are concerned, has worked very satisfactorily, and we have yet to learn of any disputes and difficulties having arisen in regard to it.

The system of buying by weight would have been incomplete without the information necessary to enable the bills to be checked up accurately being in the hands of the men, and accordingly a circular was issued to the men, giving them all the necessary information on this point. Also, at the same time this circular was issued, it was decided to dispense the oil to the service in small amounts by weight—that is to say, each engineman received a certain amount of burning oil, cylinder lubricant, and engine oil for the trip; also other branches of the service, especially where hand lanterns are required, must have an oil supply. Before the circular below was issued, this had always been done in gallons or quarts, and when the change to giving out the oil by weight was proposed, it met with some op-

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the Journal for December, is on the Work of the Chemist on a Railroad; No. II, in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these Contributions to Practical Railroad Information of special value in indicating the true character of the materials they must use and buy.

position from those in charge of the oil houses on the ground that it would take too long to weigh. A direct experiment on this point, however, proved that with an ordinary spring balance, the necessary supplies of oil could be given to 20 enginemen in about half the time by weight that it could by measure. The process is excessively simple. An engineman brings his can, containing possibly a little left over from the previous trip, and wants, we will say, five quarts of engine oil. To supply this by measure would necessitate using a gallon measure and a quart measure. To supply this by weight simply necessitates hanging the can on the spring balance, with a funnel in it, and noting the weight. Then add 9 lbs. and 5 ounces of oil, which would be indicated by simply adding that figure to the weight of the can and funnel, as it hung on the balance. In a very short time, as soon as the enginemen began to call for so many pounds of oil, the system of distributing by weight came into great favor, and has been followed with great success.

The following circular gives the information needed by the men in order to start such a system on a railroad :

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Instructions in Regard to Weight of Lubricants and Burning Oils.

All materials for lubricants and burning oils will, on and after October 1 next, be purchased and used by weight, and all requisitions for any of these materials, for purchases to be made on or after that date, must call for so many pounds instead of so many gallons or barrels as heretofore. The following are approximately the weights per gallon of different kinds of oil :

Lard oil, tallow oil, neat's-foot oil, bone oil, colza oil, mustard-seed oil, rape-seed oil, paraffine oil, 500° fire-test oil, engine oil, and cylinder lubricant, 7½ lbs. per gallon.

Well oil and passenger car oil, 7.4 lbs. per gallon. Navy sperm oil, 7.2 lbs. per gallon. Signal oil, 7.1 lbs. per gallon ; 300° burning oil, 6.9 lbs. per gallon ; and 150° burning oil, 6.6 lbs. per gallon.

The number of gallons of oil needed having been decided upon, the weight which should be called for by requisition is found by multiplying the number of gallons by the proper weight given above.

All parties furnishing lubricants and burning oils are required to mark each package with both gross weight and tare, but it is not sufficient to simply take these figures off the barrels and compare them with the bills. Every shipment of every kind of lubricants and burning oils must, as soon as received, be carefully weighed. This applies to tallow and greases, as well as all the oils used for lubrication and burning, and must be done whether the oil is subsequently emptied or not.

Wherever possible all lubricants and burning oils must be emptied at once, and the empty packages carefully weighed. In emptying, care should be taken to get all the material out of the packages. With tallow and grease, and with lard oil in the winter, this is especially requisite, and it will probably be necessary to steam out the packages.

Wherever material is shipped to other shops in the original packages, or where it is impracticable to empty them all, at least 5 per cent. of each shipment must be emptied and the empty packages weighed, the tares for the remainder of the shipment being taken from the packages themselves. If the weights of the packages, which are emptied, correspond with the marked tares, no adjustment is necessary. If they do not correspond, the tares for the whole shipment must be adjusted in accordance with the tares of the 5 per cent. which were actually weighed.

The gross weights and tares having been obtained, the net weights will appear. If the sum of the net weights thus obtained is not over 1 per cent. less than the amount charged for in the bill, the Form C may be signed in the usual way. If the deficiency is more than 1 per cent. of the amount charged for in the bill, a statement of the deficiency, together with the Form C, unsigned, should be sent to the Superintendent of Motive Power for adjustment and correction.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of the General Superintendent Motive Power, Altoona, Pa., September 12, 1885.

In regard to the above circular, the weights given for the different kinds of oil are sufficiently close to accuracy, so that no serious trouble occurs in adjusting. Moreover, the system of buying by weight eliminates all questions of capacity. The words "Form C," in the circular, are the technical words by which the duplicate bill which goes into the hands of the party receiving the material is known.

IX.—HOT BOX AND LUBRICATING GREASES.

Perhaps no subject connected with the operation of railroads causes more annoyance, not only to the public but also to the operating officers, than what are known popularly as "hot boxes." In reality it is the journal and bearing which get hot, and not the box which encloses them, and carries the waste and lubricant. Much delay of trains and annoyance in every way is occasioned by these failures of the journal and bearing to run cool, and many speculations have been indulged in as to what the cause of hot boxes, using the technical term, is, and what is the best cure. Probably not less than 50 or 60 different compounds to be used in treating hot boxes have been analyzed and examined in the Pennsylvania Railroad Laboratory during the last 15 years. These substances are known under the general name of hot-box greases, and are to be carefully distinguished from greases offered for lubrication. The lubricating greases are not supposed to be used as a cure for a hot box, but in place of oil as lubricant on certain high-speed trains. On the other hand, hot-box greases are used only when the journal and bearing get hot in service.

Upon the general question of using grease in place of oil as car lubricant, our opinion, based on a number of years' experience now, is that, all things considered, oil is far the best lubricant. It would take a careful analysis, however, of all the points involved in lubrication to make clear the basis on which this opinion rests, and it is possible later on, in this series of articles, the question of lubrication may be discussed in full. For the present it is sufficient for our purpose to say, that in all cases where the pressures do not exceed 350 lbs. per square inch of projected area on the journal, and where the speeds do not exceed 30 or 35 miles an hour average, oils are altogether the best lubricants, provided proper attention and care is given to the car boxes. On the other hand, where the pressures may reach 400 or 450 lbs. per square inch, and where the speeds run from 35 to 50 miles per hour, something a little more viscous seems to give rather better results, and consequently in modern practice, especially where high speeds are employed, there is a tendency toward the use of grease in place of oil. So far as the Pennsylvania Railroad goes, however, this tendency must be regarded as still in the experimental stage. We do not think there is anywhere in existence information which shows positively that under the same care less difficulty is experienced even with high-speed trains, which are lubricated by means of grease, than with the same trains lubricated by a good oil. However, as stated above, there is in the conditions affecting the success of the lubricant a plausible basis for the use of a little more viscous material, where high speeds and high pressures are involved, than where lower speeds and less pressures prevail, and consequently, as has already been stated, there seems to be a disposition toward the use of lubricating greases on certain trains.

The lubricating greases which we have examined have in almost every case contained more or less petroleum product as a large constituent, the petroleum product being hardened or made more viscous by the addition of tallow, lard oil, or neat's-foot oil, and in some cases by the use of some of the vegetable waxes, such as japan or carnauba wax. Also in an experimental way the petroleum products have been mixed with rosin somewhat as a means of getting a lubricant which would hold up the load a little better, and, owing to greater viscosity, have a trifle greater power of staying between the surfaces. The question of lubricating greases, however, is so unsettled that we would hardly be able to give a formula for a good lubricating grease.

Upon the question of hot-box greases there is much more information, but before we speak on this point, it might be well to devote a few words to the causes of hot boxes. Popularly among the men, the oil or lubricant used is supposed to be the cause of many of the hot boxes. Frequently the bearing metal is supposed to be at fault, some-

times the waste is blamed, and much more rarely lack of care, or lack of lubrication, or bad fitting of journal and bearing are blamed with the difficulty. To those who are not familiar with the method of lubricating car journals, it may perhaps be well to say that the bearing which holds the weight of the car rests on top of the journal, covering about three-quarters of its diameter; that surrounding both bearing and journal is the cast iron-box which rests on top of the bearing, and has considerable open space below the journal, which open space is filled with wool waste or mixed wool and cotton waste saturated with the lubricant. This box is made as close as possible behind, and fitted with what is known as a dust guard, which encloses the journal as tightly as possible on the back side. On the front side the box is opened by a lid, and the condition of the waste is examined at each inspection point, being stirred up if necessary, and fresh lubricant added. By this method of lubrication, as will be seen, the journal is dependent for the lubricant that it gets from the waste on touching the waste, and among the causes which are sometimes given for hot boxes is, "Waste too far from the journal."

Turning now to the cause of hot boxes, our own view, based on the experience and observation of a number of years, is that there may be a number of causes producing a hot box. With the lubricant in common use on freight cars, a pressure above 350 or 400 lbs. per square inch on the bearing is quite apt to lead to a hot box, due simply to over-pressure, the lubricant being not sufficiently viscous to hold the surfaces far enough apart to prevent too great interference of the surfaces with each other and consequent generation of too great heat. Again, it not infrequently happens that journals and bearings must be used which do not fit each other, as when a new bearing is put on a worn journal. This causes too high pressures on certain points, with consequent generation of more heat than can be disposed of in the ordinary way. Also it sometimes happens that the journal or bearing may contain slag or mineral matter mechanically enclosed, which causes grinding action and consequently excessive heat. Still again, when new cars go out, the journals and bearings are more or less rough, even with the best appliances for fitting them together in the shop, and consequently until they have worn off the inequalities, and have become adapted to each other, it is not infrequent that hot boxes occur. All these causes are to a certain extent unavoidable concomitants of the service, and hot boxes arising from these causes can really not be regarded as blameworthy. In our judgment, however, not over 10 per cent. of the hot boxes can be accounted for in this way. By far the principal portion of hot boxes, we think, is a direct result of lack of care, and if our theory is correct, every journal, even though supplied plentifully with lubricant, but sufficiently neglected in other respects will sooner or later run hot. The theory which we use to explain the largest portion of hot boxes is as follows: It is well known that all journals and bearings are subjected to wear, and that the portions which wear off are usually very small bits of metal, which at first simply discolor the oil. It is also well known that no car box has yet been devised which completely excludes the dust from the air. Both of these—namely, the wearings from the journals and bearings, and the dirt from the air—constantly mix with the oil or lubricant used, so that from the first moment when a new journal starts, the oil in the box is becoming more and more a mixture of mineral matter with the lubricant. If now the oil is 90, 80 or 70 per cent. and the mineral matter 10, 20 or 30 per cent. of the material which goes between the surfaces as the journal revolves, it is entirely possible that no difficulty will occur, since such a mixture is a very fair lubricant. On the other hand, as time progresses there is constant change, resulting in an increase of mineral matter, and ultimately the lubricant which goes between the surfaces becomes a mixture of 75 or 80 per cent. perhaps mineral matter and 25 or 20 per cent. of oil. Such a lubricating material is in reality a paste, and with such a lubricating material enormous amounts of heat are generated. In the common language of the shops, the journal is "dry." In actual fact the journal is lubricated with a mixture composed largely of mineral matter and a small amount of lubricant. The above explanations are based on the supposition that a journal receives no fresh supply of oil and no care, and there is no doubt, we think, but that under these conditions any and every car journal in service will sooner or later get hot. But it will be urged that no journal runs without care and constant supplies of oil added to keep down the percentage of mineral matter in the lubricant. To this we reply, the addition of oil undoubtedly puts off the evil day, and if the oil added would keep the waste clean, very few hot boxes would probably occur. But unfortunately the waste in the car box retains the mineral matter and wearings in the car boxes in spite of everything which can be done, and no amount of oil added will ever keep waste free from accumulations of mineral matter. It results even with the best of care, and constant additions of oil, unless the dirty waste is taken out and its place supplied with fresh clean waste from time to time, that the waste in every car box becomes continually more and more dirty, so that the lubricant which the journal and bearing gets is ultimately so largely composed of mineral matter that excessive heat is generated.

In proof of the theory of hot boxes advanced above, the following experimental data have been obtained. *First*, oil squeezed out of the waste of some car boxes which had been moderately warm was tested on the oil-testing machine, in direct comparison with clean, fresh oil, the amount of heat generated by the two oils, under the same conditions, being determined approximately. The result showed that the dirty oil from the car boxes generated nearly double the amount of heat that was a concomitant of the clean, fresh oil. In other words, the more mineral matter there is in a lubricant which goes between the surfaces, the greater amount of heat will be generated. This experiment can be repeated any time by any one who has the appliances, and it was repeated by us with various modifications, graphite, tripoli, and other mineral substances being purposely added to the oil, to get some idea of the relative amount of heat generated with each of these different substances as lubricant. These experiments are hardly in sufficient shape to warrant publication as conclusive results, but upon the main fact—namely, that with dirty oil more heat is generated than with clean oil, there seems to be no doubt. Moreover, this difficulty in regard to heat with dirty oil seems to be cumulative—that is to say, the warmer the journal using dirty oil gets, the more limpid the oil becomes, and the less there is of it between the surfaces, thus causing the mineral matter to be more and more continually an element in the lubrication; and, as every practical mechanic knows, when the lubricant becomes largely mineral matter, or, in technical language, the journal is "dry," very great friction results, with consequent great generation of heat.

Second, at one time, either in December or January, on a certain railroad, there was a very serious epidemic of hot boxes, so much so as to cause real difficulty with the traffic, and a very careful investigation was made as to the cause. It was finally found that during the months of September and October previous, the traffic had been so heavy that the car inspectors were not able to repack the ordinary number of cars per day with fresh waste, and that even up to the time when the epidemic occurred they had not been able to catch up. The consequence was that the car boxes were actually running on dirty waste, and although the normal amount of oil had been constantly used, the epidemic of hot boxes had resulted as above stated. A little additional force put on, and a repacking with fresh waste of quite a percentage of the equipment, caused the epidemic to disappear.

Third, on a certain railroad which runs through a very sandy country, and which, at certain seasons of the year, has a great traffic, there was great difficulty from hot boxes, due, apparently, to sand and dirt getting into the boxes. A piece of pasteboard laid in under the car box lid, over the waste, caused this epidemic to disappear. This piece of pasteboard fitted moderately tight around the edges of the box under the cover, and at the end of the run would be found covered with sand. Care being taken to throw this sand out when inspecting the boxes, no greater difficulty was experienced on this road than on others with hot boxes.

If the reasoning above is correct, it seems to follow that a large portion at least of hot boxes result from lack of sufficient care and attention to the boxes. If the waste is renewed with sufficient frequency, good appliances made use of to keep the dirt out, and a good fair lubricant used, it would seem that hot boxes might be reduced to a very small number, and we really do not know of anything which can be done that will take the place of this care and attention. Until some method of car lubrication is devised which does away with the waste, there is very little possibility of keeping the number of hot boxes to a minimum, without a good deal of expense and labor in the matter of the renewal of waste, and care of the boxes in service.

A journal and bearing having become very hot, what is the best remedy? The answers to this question are very numerous. With some the use of tallow alone is believed to be very efficacious, and we think there is no doubt that many hot boxes can be cured by the use of tallow, or indeed a car candle laid in alongside of the car journal. Others have their favorite remedy in some form of hot-box grease, which is supposed to have the power of cooling the journal if it is only put in the box, however hot the journal may be. No hot-box grease that has ever been tried, however, so far as the experience of the Pennsylvania Railroad goes, will make this claim good. Greases have been tried which cool off a fair portion of the boxes to which they are applied, but no grease which we have tried will universally cause the box to run cool after it has once become hot. The general theory on which hot-box greases are constructed is apparently to make them of such lubricating materials as will stand very high temperatures without vaporizing, and as will give a product more viscous than the oil which was in the boxes before. In our analyses of hot-box greases we have found high fire-test petroleum as an almost universal constituent. In addition to this some of them contain soaps of various kinds, lime soap being a favorite one; sometimes soda soap is a constituent, sometimes North Carolina tar is a constituent, almost always water to a greater or less extent; sometimes tallow, lard oil, neat's-foot oil, cotton-seed oil, or some other saponifiable fat, and in most cases mineral matter, either soapstone, graphite, whiting or mica. Sharp sand is also not a rare constituent, apparently not introduced on purpose, but due to carelessness in manufacture. Sulphur also frequently occurs as a constituent, and some greases which have been highly lauded as absolute cures for hot-boxes are apparently nothing but sulphur and fats. Rosin and rosin oil are sometimes used. The number of hot-box greases in the market is legion, and it is a very poor month which does not bring out from one to two new greases. We are free to confess we do not know of any grease in the market that is perfectly satisfactory.

It will be seen from what has preceded that we are strongly of the opinion that the number of hot boxes in service can be made very small by sufficient care and expense, and if this is true, the best antidote to hot boxes would seem to be to furnish the requisite care and attention. On the other hand, it will be noted that there seems to be some causes for hot boxes which are practically uncontrollable under the ordinary conditions of service, and for these hot boxes some remedy must be devised. Unquestionably if a car, the boxes of which have become hot, can be taken out of service, the boxes allowed to cool, the journals and bearings refitted and repacked with clean waste and oil, very little difficulty would be experienced with it; but this is not a possibility in the ordinary management of the service, especially the freight service. The great desideratum is some material which can be put into a box that has once become hot while it is hot, causing a few minutes' delay to treat the box, and then allowing the car to go ahead. For this purpose undoubtedly a good grease is the best thing known at present.

Our ideas as to what a hot-box grease should be may be stated something as follows:

First, it should contain no mineral matter whatever. We are quite well aware that upon this point there is a very broad difference of opinion even among experts, some claiming that after a box has become hot, especially if the bearing and journal have become scored or scratched, a little mineral matter with some lubricant serves to wear the surfaces smooth much sooner than would otherwise result. Our own view is that the addition of the mineral matter is simply laying the foundation for another hot box sooner or later, and although it works all right while the viscous lubricant which is a constituent of the grease is present, as soon as this viscous lubricant has been carried out of the box by subsequent additions of oil, the mineral matter stays to be the cause of difficulty a second time. The most experienced inspectors on the road usually prefer a grease with a little mineral matter in it, but those who are best observers claim that as soon as the box becomes cool all the grease that can be gotten hold of should be taken out of the box and thrown away. In the freight service this is impossible, and also it is very nearly impossible in the passenger service, so that we prefer to do without the possible benefit of the mineral matter in the grease while the box is cooling off, to having the resulting difficulty of the mineral matter being in the box. Moreover, definite trials have been made of greases containing no mineral matter, rather better results being obtained than with grease containing mineral matter, so that we do not know of any positive experimental data which prove that mineral matter is a valuable constituent of hot-box grease.

Second, a good hot-box grease should contain something to carry off heat. For this purpose undoubtedly water is the best substance known, and we see no reason why a good hot-box grease should not have from 20 to 30 per cent. of its weight of water as an essential constituent.

Third, after the water has evaporated it should leave a material which has a tendency to adhere to the hot surface, and which is a fairly viscous lubricant at high temperatures. Upon this point it will be noted that one of the causes given above for hot boxes is too great interference of the surfaces with each other, and this is especially true of journals and bearings after they have become somewhat scratched. If now a lubricant is used which will hold the surfaces a little farther apart, and render the interference of the surfaces a little less, much less heat will be generated, and consequently the box will have time to cool off. Most of the greases in the market fill one of these requirements fairly well—namely, they have a tendency to hold the surfaces further apart, because they are rather dense viscous substances. The adhesiveness at high temperatures is not so easy to obtain, and many of the greases of the market seem to be almost repelled by the hot surfaces.

Fourth, a hot-box grease should contain nothing that does not ultimately dissolve in the oil added afterward as lubricant. The reason for this is obvious. The grease is only added for a certain purpose, and it is not at all the best lubricant for steady use. Owing to the impossibility mentioned above of removing the grease after it has accomplished its work, we deem it an essential, therefore, that the grease should dissolve readily in the oil subsequently added to the car box. We really do not know of any grease in the market that fills this requirement. Obviously the mineral matter under no circumstances dissolves in the oil added, and a good many of the other constituents mentioned above as characteristic of hot-box greases in the market do not dissolve in oil.

Experiments are in progress on the Pennsylvania Railroad with various greases, which approximate the conditions mentioned above, and thus far the results seem very favorable. The usual method of treating hot-box greases is to take a barrel of the grease at some inspection point, and treat every hot box that comes along to that point on freight trains with a proper amount of the grease. The box is then allowed to go ahead, even though it may be more or less hot when it starts. A record is kept, and 35 or 40 miles from this place an observation is made as to whether the box is cooled off or not under this treatment. Usually an experiment embraces 100 hot boxes, and the results obtained show that with different greases, all the way from 50 to 75 or 80 per cent. of the boxes treated are cooled off.

There is much need of study on a method of car lubrication. The "waste method," if it may be so called, is defective in many respects, and the man who will devise a

successful and at the same time simple method of car box lubrication that does away with the waste will not only prove a great benefit to the railroad world, but will also have a good show of securing substantial reward.

The next article of the series will treat of battery materials, including zinc, sal ammoniac and sulphate of copper.

(TO BE CONTINUED.)

AUTOMATIC BACK-PRESSURE RELIEF VALVE.

A LATE number of the *Engineer* contains the following engraving and description of a relief valve, which may interest some of our readers, as a similar scheme has been tested in this country some years ago. Our contemporary says: "The accompanying engraving, fig. 1, illustrates a new combined drain cock and relief valve, patented by Mr. W. Wood, Summerfield-crescent, Birmingham. The engraving shows the valve at work. The steam entering the cylinder at *A* closes the valve at that end, at the same time opening the opposite end *B*, and *vice versâ* with the motion of the piston, allowing any water that may accumulate in the cylinder to pass out into the drain. The valve is always open in the same direction that the piston is traveling, which prevents accidents through priming, or neglecting to open the cylinder cocks. Its simplicity of con-

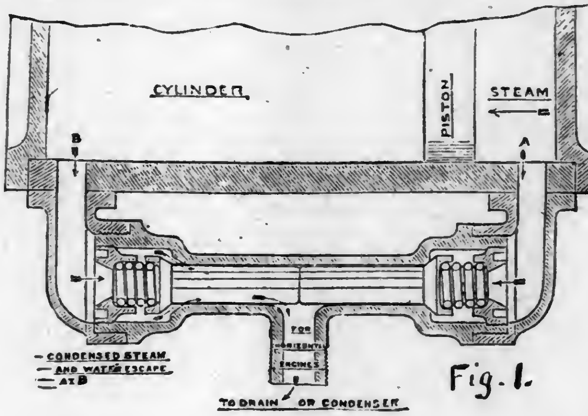


Fig. 1.

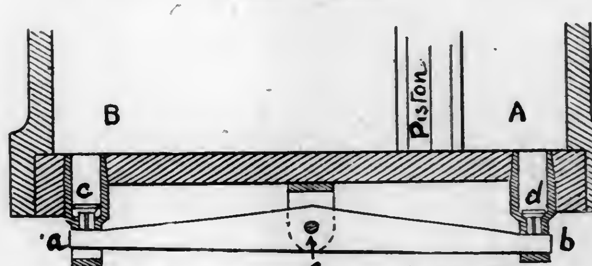


Fig. 2.

struction renders it impossible to get out of working order —it is made of hard gun-metal. The advantages claimed are: (1) It dispenses with the two ordinary cylinder cocks now in use, which leak or become corroded; (2) the water is automatically taken away, as it accumulates in the cylinder; (3) the valve is always open when the engine is standing, and thereby prevents accident when starting through neglect in opening the ordinary cocks; (4) any back-pressure caused by the steam passing the piston, or water introduced by priming, finds instant relief, thereby dispensing with relief valves in the ends of the cylinder, and reducing the breaking of joints to a minimum; (5) it is perfectly automatic and direct-acting.

About 30 years ago Mr. William Buchanan tested a similar device on the Hudson River Railroad. Fig. 2 is a drawing, made from memory, of the device he used. It consisted of two conical valves *c* and *d*, at the ends of the cylinder. These valves rested on the ends of a lever *a b*, which was pivoted at *e*. When steam was admitted into the cylinder at *A* it pressed the valve down on its seat and closed it. At the same time it depressed the end *b* of the lever and raised up the opposite end *a* and the valve *c* and opened it. The reverse operation occurred when steam was admitted at the opposite end *B* of the cylinder.

The interesting result was that when this device was applied to the locomotive, it was found that it thumped badly, and, as Mr. Buchanan reports, nearly hammered itself to pieces. The engine with this device on it did not run nearly as well as it did before, and would not make either time or steam. It was a practical exemplification of the value of compression to the successful working of a locomotive.

UNITED STATES NAVAL PROGRESS.

THE new gunboat *Bennington* was launched at the Roach Yard in Chester, Pa., June 4. The *Bennington* is 230 ft. long, 36 ft. beam and 1,700 tons displacement. She has twin screws, driven by two triple-expansion engines, with cylinders 22 in., 31 in. and 50 in. in diameter and 30 in. stroke. She will carry six 6-in. breech-loading rifled guns, eight small rapid-fire guns and eight torpedo-tubes. The *Bennington* is in all respects like the *Concord*, which was described and illustrated in the April number of the JOURNAL, page 168.

Bids were received at the Navy Department in Washington, June 10, for three new ships. The first and largest—which is the largest vessel yet designed for the Navy—was the armored cruiser, No. 2, of 8,100 tons displacement, a description of which was given in the April number of the JOURNAL. For this ship five bids were received, as follows:

The William Cramp & Sons Ship & Engine Building Company of Philadelphia, on the plans and specifications of the Navy Department, $3,150,000; on plans and specifications submitted by themselves, $2,985,000.

The Union Iron Works, San Francisco, on the Department plans, $3,100,000; on their own plans as submitted, $3,000,000.

The Risdon Iron & Locomotive Works, San Francisco, on the Department plans, $3,450,000. This company has never done any naval work. The appropriation limit for the ship is $3,500,000.

The second ship is officially designated as cruiser No. 6, and is a protected cruiser of 5,500 tons displacement. This ship was described in the June number of the JOURNAL, and will be of the same type as the *Baltimore, Philadelphia, Newark* and *San Francisco*, but larger, having about 1,000 tons more displacement. For this vessel only two bids were received, both from the Union Iron Works, San Francisco, who offered to construct the ship on the Department plans and specifications for $1,796,000, or, according to their own plans, for $1,760,000. The appropriation limit for this ship is $1,800,000.

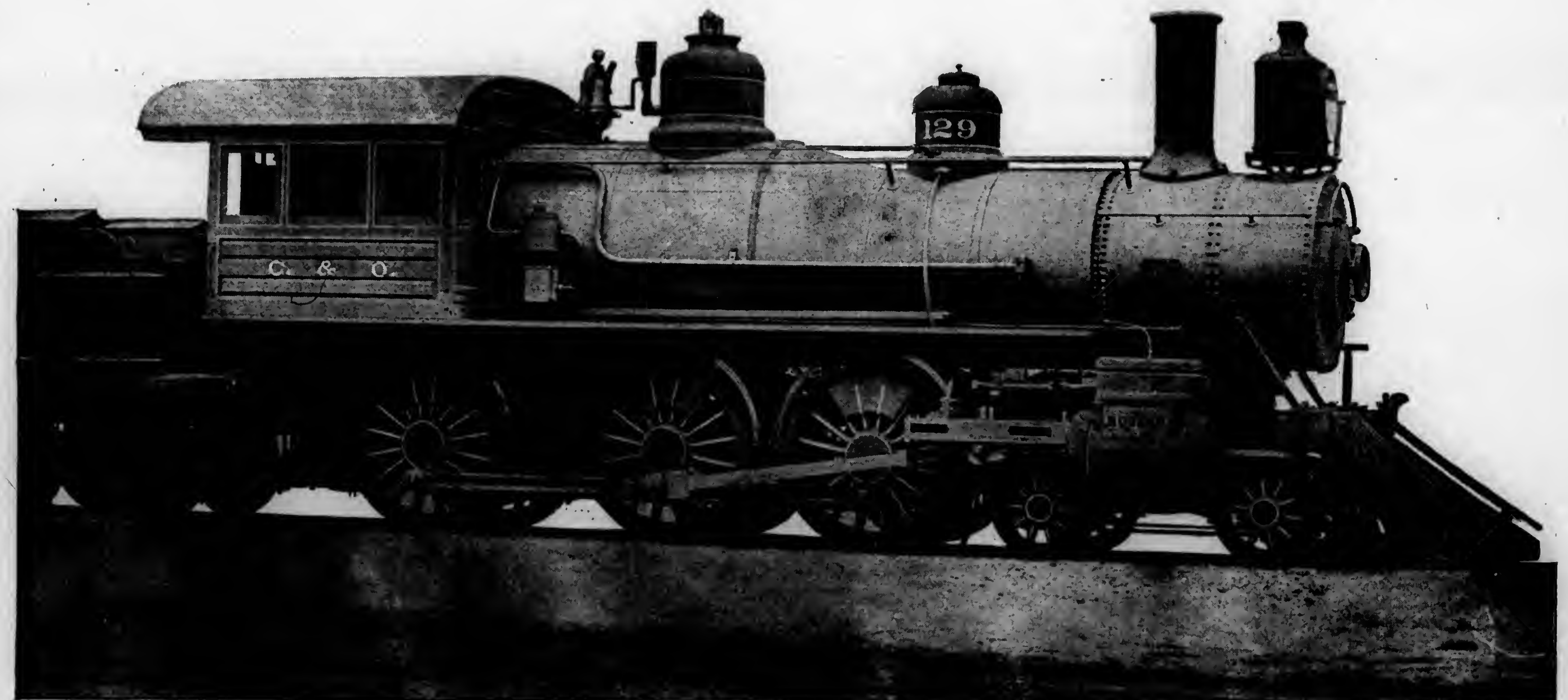
The third vessel bid for was the practice ship for the Naval Academy. Bids had been received for this vessel previously, but no contract was let, and new bids were called for. This is a small ship of 800 tons displacement, and of very similar type to the gunboats Nos. 5 and 6. She will be 180 ft. in length, 32 ft. breadth, 11 ft. 6 in. mean draft, with triple-expansion engines of 1,300 H. P. Owing to the purpose for which she is intended, she will have an unusual amount of work upon her for a small vessel. Two bids were received for this ship: one from F. W. Wheeler of West Bay City, Mich., for $245,000; the other from Samuel L. Moore & Company of Elizabethport, N. J., for $250,000, both on the Department plans. The appropriation limit is $260,000.

The Department has awarded the contract for armored cruiser No. 2 (the 8,100-ton ship) to the Cramp & Sons Company on their second bid of $2,985,000, accepting the changes in design proposed by them. The contract for cruiser No. 6 (the 5,500-ton vessel) is given to the Union Iron Works, San Francisco, on their first bid of $1,796,000, on the Department plans. Samuel L. Moore & Company receive the contract for the practise ship on their bid.

ENGINEERING IN THE FAR EAST.

OUR correspondent in Siam, who has been actively engaged in engineering work in that distant country, writes:

I am sorry to say that railroad affairs in Siam have not progressed since I last wrote to you. The Borapah Railroad Company was reorganized on a broader financial



TEN-WHEEL PASSENGER LOCOMOTIVE FOR THE CHESAPEAKE & OHIO RAILROAD.

BUILT BY THE ROGERS LOCOMOTIVE & MACHINE WORKS, PATERSON, N. J.

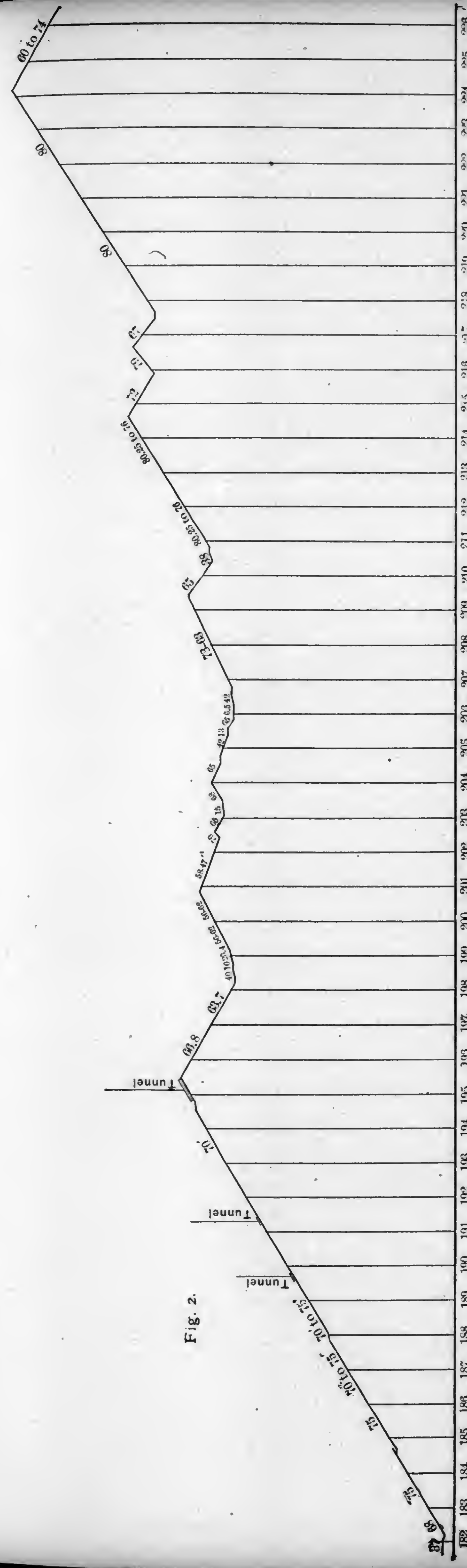


Fig. 2.

and physical basis—the gauge of the proposed line being changed from narrow to standard—and an offer was received from Punchard & Company, of London, to take half the company's stock, provided they were given the construction for a consideration of 10 per cent. on the cost; but the offer seems to have been declined, and at present the chances of any railroad construction here appear remote. The need of means of internal communication becomes daily more apparent, and foreigners of several nationalities would jump at the chance of building lines on terms decidedly favorable—all things considered—to the Siamese Government; but the Oriental mind loves the policy of much promise and little performance, and seems to suspect a trap in each proposal, no matter how fair-seeming it may be to Europeans.

The only railroad here—the Bangkok Tramway, worked by ponies—pays famously, and is now being considerably extended. The track is excellent, a deep rail with grooved head, laid on metal cross-ties. The brakes on the cars are operated by the foot, and warning to pedestrians is given by a bugle, which suits the Siamese—a very musical people—is efficient and less offensive than a gong, besides being very distinctive.

The Siamese are a lively people, found of traveling and much given to using such public conveyances as are within their reach—now very few in number.

A TEN-WHEEL PASSENGER ENGINE.

THE accompanying illustration shows a passenger engine of the ten-wheel type recently constructed by the Rogers Locomotive & Machine Works of Paterson, N. J., for the Chesapeake & Ohio Railroad. The work to be done by this engine is to take what is known as the vestibule train of the road over the mountain section. The average speed at which this train is expected to run is 32 miles an hour, and the train ordinarily consists of nine cars—one baggage, one mail, three passenger cars, one dining car and three sleeping cars. The accompanying sketch, fig. 2, is a profile showing the grades upon this section of the road; and these engines have worked very successfully over the grades.

The general type and construction of the engine is well shown by the photograph. The cylinders are 20 in. in diameter by 24 in. stroke. The steam-ports are $1\frac{5}{8}$ in. × 20 in. and the exhaust-ports $3\frac{1}{4}$ × 20 in. The slide valve is of the Morse-Allen balanced pattern, with $\frac{7}{8}$ in. outside lap, $\frac{1}{16}$ in. inside lap, and a maximum travel of $5\frac{1}{2}$ in. The driving-wheels are 62 in. in diameter, with steel tires 3 in. thick on the thread. The tires of the forward pair of wheels have no flanges. The driving axles have journals 8 in. × $9\frac{1}{2}$ in. The truck is of the swing pattern, having Allen steel-tired wheels 33 in. in diameter. The truck axle journals are 5 in. × 10 in. in size.

The guides are of the three-bar pattern of steel, the top guide being $12\frac{1}{2}$ in. × $1\frac{3}{4}$ in. in section and the bottom guides each 3 in. × $2\frac{1}{2}$ in. The cross-head is of cast steel, fitted with brass gibs, and the bearing of the cross-head pin is $3\frac{1}{2}$ in. × $3\frac{1}{2}$ in. The main crank pin is $5\frac{3}{4}$ in. in diameter and 5 in. long; the side-rod pins are $5\frac{1}{2}$ in. in diameter by 6 in. in length. The main rod is of the ordinary pattern; the side rods are of steel fluted, and made with solid ends provided with Phosphor-Bronze bushes.

The frames are of the ordinary bar pattern. The engine is provided with driver brakes fitted with the American outside equalized brake, the levers being operated by Westinghouse automatic air-brake cylinders.

The boiler is of the wagon top type with long fire-box, the barrel being 62 in. in diameter. The fire-box is of steel, is 33 in. in width inside and 132 in. long, its depth in front being $75\frac{1}{4}$ in. and at the back $61\frac{3}{4}$ in. The crown-sheet is supported by radial stay-bolts. The fire-box is furnished with a brick arch supported by four water-tubes. There are 272 tubes 2 in. in diameter and 13 ft. 6 in. long. The grate area is 30 sq. ft.; the heating surface is: Fire-box, 188 sq. ft.; tubes, 922 sq. ft.; total, 2,110 sq. ft. The fuel used is soft coal, and the ordinary working pressure is 170 lbs. The rear driving axle is carried under the fire-box.

The tender tank has a capacity of 3,500 galls., and the

tender is carried on Boies steel-tired wheels 36 in. in diameter.

The total weight of the engine in running order is 132,700 lbs., of which 102,800 lbs. are carried on the drivers and 29.900 lbs. on the truck. The total weight of the tender in running order is 72,000 lbs., so that the total weight of engine and tender is a little over 102 tons.

It may be noted that the ten-wheel type is growing in favor for passenger engines designed for heavy work, and is now being introduced on a number of leading roads.

AERIAL NAVIGATION.

By O. Chanute, C.E., of Chicago.

(A lecture to the students of Sibley College, Cornell University; delivered May 2, 1890.)

Until quite recent years, the possible solution of the last transportation problem remaining for man to evolve—that of sailing safely through the air—has been considered so nearly impracticable that the mere study of the subject was considered as an indication of lunacy.

And yet such measurable success has recently been achieved as to warrant good hopes for the future, and it is believed that speeds of 25 to 30 miles per hour, or enough to stem a wind less than a brisk gale, are even now in sight.

This is not unusual in the history of inventions. They are first proposed by the men of imagination, the poets and the dreamers, and next they are experimented upon by the more imaginative inventors, until at last some glimmer of success or some powerful incentive induces scientific men to investigate the principles, and ingenious inventors to endeavor to solve the problem.

Thus, if we are to believe ancient fable and history, desultory attempts to fly through the air followed close upon the invention of the land chariot and of the marine sail, but the mechanical difficulties in the way are so great that it is only since light primary motors have been evolved that any success at all has been achieved; and even now the students of the problem are divided into two camps or schools, each of which expects flight to be compassed by somewhat different apparatus. These are:

1. Aeronauts, who believe that success is to come through some form of balloon, and that the apparatus must be lighter than the air which it displaces.

2. Aviators,* who point to the birds, believe that the apparatus must be heavier than the air, and hope for success by purely mechanical means.

Curiously enough, there seems to be very little concert of study between these two schools. Each believes the other so far wrong as to have no chance of ultimate success.

Their work will be described separately; and first that of the *Aeronauts*, in which it will be necessary to describe chiefly French achievements, that nation having taken the lead hitherto in studies aerial, probably in consequence of the invention of the balloon by Mongolfier in 1793.

AERONAUTS.

This great step (as it is believed to be) toward a possible solution of the problem at first excited the wildest hopes. Many believed the navigation of the air to be an accomplished fact. These hopes faded it was soon found that an ordinary spherical balloon was at the sport of the wind; and all sorts of impracticable devices were tried to control its motions, save till quite recent years (1852) that of furnishing it with a screw and an energetic motor.

While it is possible to impart low velocities, in calm air, to any kind of a balloon, yet the motive power which it could lift has been so small, and the consequent speed so inferior to that of ordinary winds, that until 1884 no balloon had ever come back to its starting-point.

We can perhaps best realize this deficiency of motive power by calculating approximately the speed which can be imparted to a spherical balloon by the motor it is capable of lifting; and instead of selecting one of those generally employed in ascensions, of 30 or 40 ft. diameter, we will take as an illustration the great captive balloon built and operated by Giffard during the French Exposition of 1878, which was one of the largest and best ever built.

This was 118 ft. in diameter. Its volume was 882,925 cubic feet and its gross ascending power was 55,120 lbs. As the weight of the balloon proper, its car, appurtenances and fixtures was 30,536 lbs., there remained a net ascending power of 24,584 lbs., which might be utilized for a motor, its supplies, and a cargo.

Let us first calculate the resistance of the air to its motion.

Being a sphere 118 ft. in diameter, the area of its mid-section was 10,936 sq. ft. This would not, however, offer the same resistance as a flat surface, the experiments of Hutton and of Borda having shown that the resistance of a sphere is 41 per cent. of that of a flat surface of area equal to its mid-section.

But to this is to be added the surface of the car and rigging, as well as that of the motor, its framing and machinery conveying power to the propeller. This is generally found to be equal to about $\frac{1}{10}$ the area of the balloon, and as the surfaces are mostly flat, the resistance is usually estimated at 50 per cent. that of a flat plane. Reducing these two factors to their equivalent flat feet, we have:

For the balloon: $\frac{10,936 \times 41}{100} = 4,484$ sq. ft.

For the carete: $\frac{10,936 \times 50}{10 \times 100} = 546$ " "

Total equivalent flat surface .... 5,030 sq. ft.

We know by Smeaton's tables of air pressures that at a speed of 1 mile per hour the pressure upon a flat surface is 0.005 lb. per square foot, so that at this speed we may estimate the resistance of the balloon to be $5,030 \times 0.005 = 25.15$ lbs.—that is to say, that a force of but 25.15 lbs. continuously exerted would be sufficient to impart a speed of 1 mile per hour to this great mass in still air; and as this velocity is 88 ft. per minute, we have for the power required:

$$25.15 \times 88 = 2213.2 \text{ feet-lbs., or } 0.067 \text{ H. P.}$$

This seems small indeed, but as the power required increases as the cube of the speed, let us see how fast the balloon can be driven by any available motor.

The net ascending power is 24,584 lbs., but not more than half of this (as shown by the subsequent practice of Renard and Krebs) is available for the motor. The remainder is required for the framing, the propeller, the transmitting machinery, the stores of fuel or supplies and the aeronauts. We will assume therefore 12,584 lbs. for the weight of the motor proper, and that this weighs but 110 lbs. per H. P., as was the case with the steam-engine used by Giffard in his navigable balloon of 1852. The possible H. P. is therefore:

$$\frac{12,584}{110} = 114.4 \text{ H. P.}$$

If we suppose this to be exerted through an aerial screw, inasmuch as the best that has yet been publicly tried gives out but 70 per cent. of the power applied (the remainder being lost in slip), we shall have for the real available power $\frac{114.4 \times 70}{100} = 80$ H. P. But as the resistance in still air requires an effective H. P. of 0.067 H. P. at 1 mile per hour, and the power required increases as the cube of the speed, we have

$$0.067\, V^3 = 80;\; V = \sqrt[3]{\frac{80}{0.067}} = 10.6 \text{ miles per hour,}$$

as the utmost probable speed which could have been obtained with the most energetic motor which this great balloon could have taken up into the air.

How far this would fall short of stemming the prevailing winds will appear from the inspection of the following table, quoted by M. Gatendorf as the average velocities of wind observed during a period of ten years in Germany, there being during that time:

82	days of wind not exceeding	11.18 miles per hour.
244½	" " " " "	22.37 " " "
38	" " " " "	42.50 " " "
½	day " " " "	89.48 " " "

* From *avis*, a bird. This comparatively recent French term seems so appropriate as to warrant its adoption into English.

So that the occasions would indeed have been few upon which this air ship could have made any headway; yet had its possible speed been 25 miles per hour, it might have gone out about three-quarters of the days in the year; but in order to attain this speed it would have required a motor of nearly 1,500 H. P., which evidently it was quite impossible for it to lift.

Moreover, the recorded wind velocities are generally observed near the surface of the ground; but at comparatively moderate altitudes, say 1,000 to 1,500 ft. above the earth, they are much greater. Records kept at the top of the Eiffel Tower for 101 days (June to October, 1889) show an average velocity of 15.75 miles per hour, while a similar instrument 925 ft. lower down registered during the same time an average speed of but 4.90 miles per hour, or less than one-third of that at the top, 994 ft. in the air.

It is probably for lack of a realizing knowledge of this peculiarity that so many past experiments with navigable balloons have proved such disappointments. The aeronauts measured the speed of the wind at the surface, and only went up into the air to be swept away by a swifter current.

In view of the fact that wind velocities are much greater at sailing heights than at the surface of the ground, the opinion may be expressed that aerial navigation cannot be accounted even a partial success until a velocity of 30 miles per hour is obtained; but in order to remain well within the bounds of possibilities, the comparisons hereafter to be made will be based upon a speed of 25 miles per hour.

This brings us naturally to inquire as to what has thus far been done. It is clear that nothing was to be expected from any attempt to drive spherical balloons; that the resistance must be diminished in some way; and yet it took 79 years for aeronauts to realize the fact; for although General Meusnier had proposed them, and Robert Brothers had experimented with elongated balloons as early as 1784, it was not until 1852 that Henri Giffard, the future inventor of the injector, laid down the foundation for eventual success by ascending with a spindle-shaped air ship driven by a steam-engine.

GIFFARD'S BALLOON OF 1852.

On September 24, 1852, Giffard, then a young engineer 27 years of age, ascended from Paris in an elongated balloon filled with ordinary coal gas, driven by an aerial screw propeller actuated by a steam-engine of his own designing. He was at that time quite poor; but having been possessed since the age of 18 with the conviction that success was possible, he had communicated his enthusiasm to two of his college friends, who possessed limited means, and the three had contrived, amid many discouraging difficulties, to build and to equip this first navigable balloon.

It was in shape a symmetrical spindle, 144 ft. long and 39 ft. in diameter. The screw was three bladed and 11 ft. in diameter. The steam-engine was of 3 H. P., and weighed with the *empty* boiler 330 lbs., or 110 lbs. per H. P. In proportion to its power, this engine was much lighter than any previously built; but it was the utmost weight of motor which the balloon could lift, after making due allowance for the weight of the apparatus, its appurtenances, the aeronaut, the fuel, and the water. For the two latter 678 lbs. were allowed, of which 132 lbs. were in the boiler. Coke was employed as fuel, and the danger of setting on fire or exploding the gas escaping from the balloon was guarded against by surrounding the grate with a tight ash-pan, which again was surrounded with a vertical flue sheet. Thus no flame came into contact with the outer air, and the products of combustion, cooled in the return flue, were projected downward through an inverted smoke pipe, into which the steam from the cylinder was exhausted.

The cubic contents of the air ship were about 88,300 cub. ft., and being inflated with coal gas, its lifting power was 3,978 lbs. Had pure hydrogen been used instead, the lifting power would have been about 6,160 lbs., and a heavier motor could have been used; but this would have made little practical difference in the results as to speed. Fig. 1. is a side view of the entire apparatus. The surplus lifting power being only sufficient to carry up one man, Giffard went up alone, at about 5.15 in the evening. The wind on the day previously selected for the ascension blew with considerable force, and Giffard knew from his calculated resistances that he could not hope to stem it; but having attained an altitude of about 5,000 ft., he set the engine in motion. With 110 revolutions of the screw per minute, he was enabled to get a proper speed of the apparatus, which he estimated at 4.27 to 6.70 miles per hour, so as to deflect and turn the balloon from the line of the wind; and thus, while satisfied that this first air ship was quite unable to cope with the wind that day or with those generally prevailing, he yet was enabled to announce his deliberate conclusion that ultimate success was certain with a larger balloon and a more energetic motor.

He further expressed his belief, as a result of this experiment, "that the danger resulting from the juxtaposition of fire and an inflammable gas might prove to be quite illusory;" but yet no other aeronaut since his time has dared to repeat the experiment.

He came down in safety just after dark, though not without some danger. It was clear that in order further to reduce the resistances a still more elongated balloon would be required, and he resumed his studies and designs for further experiments with unimpaired enthusiasm; but the means of himself and friends were so far exhausted that it was only in 1855 that he was enabled to make a second trial with what he considered an improved apparatus.

This new balloon was 230 ft. long and 33 ft. in diameter, being thus 7 to 1 instead of $3\frac{2}{3}$ to 1, as in the former experi-

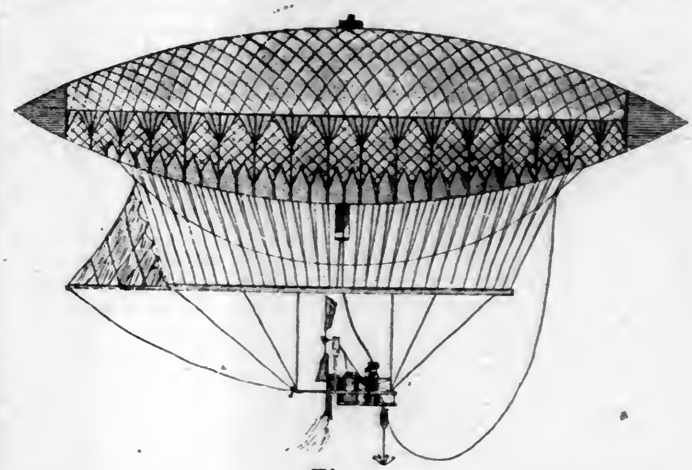


Fig. 1.

ment. This change, which was made to reduce the resistance, resulted in such longitudinal instability as nearly to cost Giffard his life. He was on this occasion enabled to take up a companion (M. Gabriel Yon) to assist in the manœuvres, but notwithstanding this, the balloon would not keep a level keel. The wind blew, and although he attained greater speed than on the former occasion, he was unable to stem the current for more than a few minutes at a time, with all the power of his engine. One end of the balloon tipped up, and the flow of the gas toward that end aggravated the evil. The valve was at once opened, and the aeronauts came down as rapidly as they could; but just as the ground was struck with considerable violence, the gas bag, tipping up more and more, slipped out of the netting and went to pieces.

This accident did not alter Giffard's conviction of ultimate success, but he determined first to make a fortune. He shortly thereafter invented the injector and eventually became a millionaire, while at no time did he abandon his aeronautical studies.

In order to work out practically all the details as to gas-tight envelopes, stability, appliances, manufacture of hydrogen, etc., he built in 1867 the great captive balloon for the Paris Exposition of that year. In 1868 he built one in London, and again in 1878 he carried out further improvements in a new captive balloon at the Paris Exposition, this being the one which has already been alluded to.

At length, in 1881, he determined upon the construction of a gigantic air ship, to contain 1,766,000 cub. ft. of hydrogen and to cost $200,000, out of which he expected a

speed of nearly 45 miles per hour; but he was near the end of his career. First his health failed, and then his eyesight; he became a recluse; and finally, discouraged and maddened by physical pain, he died by inhaling chloroform in April, 1882.

Giffard was thus the first to drive a balloon with a motor, and this he did with a steam-engine. It is probable that men before now have gone into a powder magazine with a lighted torch and have come out in safety; still the practice is not to be commended. So Giffard went up with a lighted steam furnace under a gas bag open to the air through its lower valve and he came down safely not once only, but twice; and yet other aeronauts believe the practice so dangerous that not one thus far has repeated the experiment.

THE DUPUY DE LÔME BALLOON, 1872.

During the siege of Paris, in 1870, some 65 ordinary balloons left the beleaguered city, but notwithstanding many efforts, not one of them succeeded in getting back. The Government decided in October upon building a navigable balloon, to restore communications, and entrusted its construction to M. Dupuy de Lôme, Chief Naval Constructor, to whose skill was largely due the success of the earlier armored ships of France. He went most carefully into the questions of balloon resistances, stability and working details, and pushed the construction as fast as the disorgan-

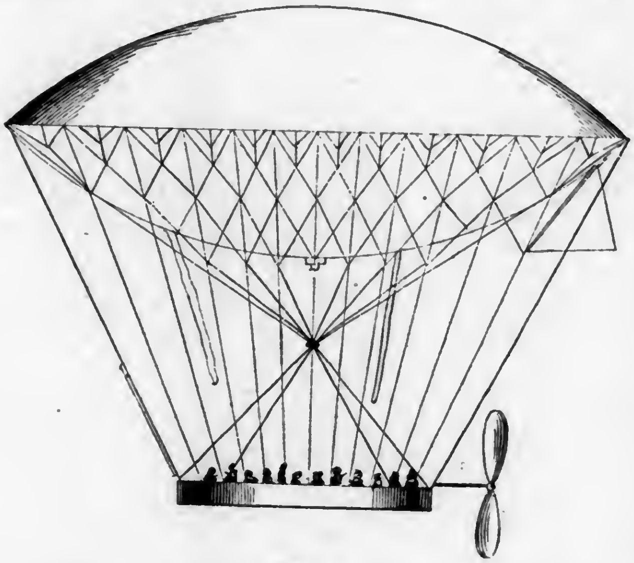


Fig. 2.

ized industry of the city would permit; but nevertheless the apparatus was completed only a few days before the capitulation.

Then came the insurrection of the "Commune," so that it was only on February 2, 1872, that the merits of the air ship could be tested.

The balloon was also a symmetrical spindle, 118⅓ ft. long and 48⅗ ft. in diameter (2.43 to 1). It contained 120,088 cub. ft. of pure hydrogen, and its lifting power was 8,358 lbs. Its principal features of novelty were a system of triangular suspension, by which all weights were concentrated at a single point a short distance above the car, and the introduction inside of the gas bag of an air pocket or bag, say one-tenth in cubic displacement of that of the balloon, so as to keep it distended and rigid at all times, by blowing in or letting out air. This valuable device was found to remove, for low velocities at least, the danger of deformation from end thrusts or resistance of the air. We shall find it used again in the Renard and Krebs experiments of 1884–85. Fig. 2 is a side view of this air ship.

Dupuy de Lôme's ultimate purpose was that his balloon should be driven with an engine of some sort; but from a wholesome dread of fire, he tried his experiment with hand power. The total crew consisted of 14 men, of whom 8 laborers turned a winch, imparting 27½ revolutions per minute to a two-armed aerial screw 29½ ft. in diameter. This drove the apparatus at a speed estimated at 6.26 miles per hour, with an expenditure of say 0.8 H. P. It is believed that the speed was overestimated, but in any event it proved insufficient to stem the wind on the day of the trial. Dupuy de Lôme estimated that by substituting a steam-engine of 8 H. P., representing the weight of 7 men, or say 1,200 lbs., he could obtain a speed of 13⅓ miles per hour; but the experiment was not made, and the next in date was

THE TISSANDIER ELECTRICAL BALLOON, 1883.

Impressed with the belief that recent improvements in electrical engines afforded a safe and convenient motor for balloons, M. Gaston Tissandier, the distinguished author and aeronaut, constructed in 1883, with the co-operation of his brother, a navigable balloon 92 ft. long and 30 ft.

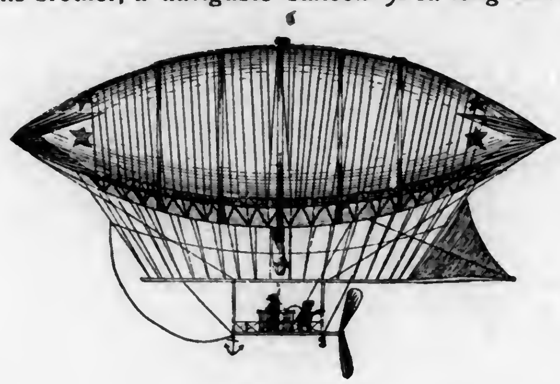


Fig. 3.

in diameter (3.04 to 1), inflated with 37,439 cub. ft. of hydrogen, and with a lifting power of 2,728 lbs.

The netting in this case was formed of flat ribbons sewed to longitudinal gores, which arrangement was found materially to diminish the air resistance due to the ordinary twine netting. The apparatus was driven by a Siemens dynamo weighing 99 lbs., actuated by a primary battery (bichromate of potash) weighing 517 lbs. more and capable of developing 1½ H. P. for 2½ hours. The screw was 9.18 ft. in diameter, with two arms, and was rotated at 180 revolutions per minute. Fig. 3 shows this apparatus.

Two ascensions were made. The first was on October 8, 1883. On this occasion there was almost no wind at the surface, but at a height of 1,600 ft. it was blowing at the rate of about 6.7 miles per hour. It was found that the apparatus was just able to stem it, exerting the full power of the motor. After performing various evolutions the aeronauts came down, intending to go up again the next day; but the weather being cool, the bichromate solution froze during the night, and although the balloon had apparently lost no gas, it was decided to empty it and to try it again after making some modifications in the rudder, which had not been found to work well.

The second ascension took place September 26, 1884, and on this occasion the balloon was found to obey its helm perfectly, to perform various evolutions and to attain a speed which, although inferior to that of the wind that day, was estimated by M. Tissandier at 9 miles per hour. This probably was also an overestimate. The longitudinal stability was satisfactory, and the necessary endwise rigidity was secured by maintaining an internal compression in the gas bag by means of a safety valve.

In neither trial could the air ship return to its starting-point because of the wind, and the results were so far inferior to those obtained at about the same time by the French War Department, that these costly experiments, which had been carried out at private expense, chiefly in the interest of science, by two gentlemen of limited means, were not prosecuted further. They had pointed out the way, and established that by the substitution for steam of electric power, the following advantages were gained:

1. All danger from firing the gas was avoided.
2. The apparatus did not vary in weight.
3. The motor was more easily managed.

Others stepped in with abundant backing to carry on the evolution of the problem.

(TO BE CONTINUED.)

TUBULOUS BOILERS.

(Paper read by Assistant Engineer S. H. Leonard, U. S. N., before the American Society of Naval Engineers, and published in the *Journal* of the Society.)

ONE of the most important questions arising in connection with marine machinery at the present time is that concerning the improvement of the steam generator. The Scotch boiler, now in universal use, leaves much to be desired even at present pressures, and if quadruple-expansion engines are soon to supersede the triple type, as now seems highly probable, steam of 225 to 250 lbs. pressure per square inch must be supplied, necessitating a radical change in the general type of boiler from that now in use.

At the present time, with but few exceptions, quadruple-expansion engines are working at a pressure of 180 lbs. only. This is accounted for by the fact that hitherto it has been found impossible to construct a marine boiler capable of withstanding pressures much exceeding 160 lbs. without considerably reducing the diameter or increasing the thickness of the shell plates. A reduction of diameter is obviously a backward step, while steel plates 1¼ to 1⅜ in. thick are about the maximum capable of being worked with satisfaction on the one hand, or of being used for the transmission of heat on the other.

In connection with the reduction of diameters, boilers of the locomotive type have frequently been tried, and some engineers are looking to this class of boiler as offering some advantage in regard to reduced weight, as well as in their adaptability to increased pressures. Their performances, however, up to the present time have been far from satisfactory; many accidents have occurred on board the torpedo-boats fitted with them, several of which were fatal; and serious leaks about tubes and seams develop after a short period of rapid steaming under forced draft. In several cases where they have been fitted in battery, they proved costly failures, the cases of the English torpedo ram *Polyphemus* and the *Flavia Gioga* of the Italian Navy being notable. Although the *Lepanto*, of the Italian Navy, has recently been fitted with 16 boilers of the locomotive type, in battery, and a favorable report made on their trial, little seems to have been proved thereby, as the conditions were far from severe. As the *Lepanto* is a ship of over 15,000 tons displacement, and the trials took place in smooth water, the boilers were perfectly steady, and consequently there was no uncovering of heating surfaces with the attending evils, so great in this type of boiler. The safety valves were loaded to the very moderate pressure of 60 lbs. per square inch. The speed trials seem to have been of rather short duration, and yet after each forced draft trial the boilers had tubes leaking.

Many are looking to the type known as the water-tube or tubulous boiler for the solution of this question of higher pressures. This certainly has many advantages claiming attention, which may be itemized as follows:

Higher pressures.—One of the most important features of this type of boiler is its capability of working at any pressure which can be utilized by the steam engine, and at the same time the danger from explosion is greatly reduced.

Weight.—As the parts of the boiler are small, the scantlings may be light and the requisite factor of safety retained, while at the same time a more free transmission of heat from the fuel to the water is secured. The water in the tubulous boiler averages from 5 per cent. to 15 per cent. of the weight of the empty boiler, while in the Scotch type the average is from 60 to 65 per cent.

Rapidity of generating steam.—The large and effective heating surface, together with the small bulk of water, which has a rapid circulation, enables this type of boiler to generate steam very rapidly without injury thereto, which is always a great advantage, and especially so in naval vessels.

Facility in making repairs.—The parts, being small and comparatively light, can readily be carried in duplicate and fitted, when necessary, with little expenditure of time or skill.

The Thornycroft boiler, it is stated, has attained, with natural draft, an efficiency of 87 per cent. of the theoretical evaporation, which is believed to be the highest result on record.

The principal requisites of a tubulous boiler are:

1. *A free and natural circulation.* The serious lack of this property in the earlier water-tube boilers built from 1870 to 1875, and fitted in the *Montana, Propontis, Birkenhead, Meredith, Marc Antony* and other ships, was the primary cause of their disastrous failures. Circulation, in order to be natural, should be a systematic motion of the water from the upper to the lower part of the generator, and thence again to the surface, the steam when formed having a free and direct flow to the steam chamber or drum, and there being an equally free and direct flow for the water displacing it. In the later successful water-tube boilers every means is taken to facilitate this cycle of operations. Downcast pipes are provided to effectually prevent any confusion or want of order in the general circulation, and as the flow in these pipes is always to be in one direction, downward, they should be so placed as to be free from any causes, however slight, tending to produce an opposite flow. In the older forms of boiler the circulation depended upon slight variations of density of the water in its different parts, and although its motion might be energetic during rapid ebullition, it was without system or order; each drop of water was struggling to get somewhere or anywhere, and continually in conflict with its neighbor. This is practically the circulation going on in the ordinary Scotch boiler, and is very different from the systematic rotation taking place in a well-designed tubulous boiler.

2. *A positive feed supply.* In this class of boiler, with such a small water capacity, where the feed must be continuous and yet variable in amount, some kind of automatic device becomes necessary to assist those in charge, and this is especially a matter of concern when they are worked in battery.

3. *Pure water.* The necessity for pure water is certainly as great as, if not greater than with other types of marine boilers. It is said that the tubes and other heating surfaces of the tubulous boiler are subject to rapid pitting and corrosion. It will probably be remembered that all forms of marine boilers were subject to the same failing in the early days of surface condensation, and indeed until means were adopted to check or arrest it. Such means seem to have been wholly or in part neglected in many of the water-tube boilers, with the result that might have been expected. If the same means and care are adopted in each case, there would seem to be no good reason why one boiler more than the other should be subject to this action.

4. *Care.* The life of a tubulous boiler will certainly be short without intelligent and systematic care. If builders would bear this fact in mind and use their ingenuity in making all parts of their inventions more easily accessible for frequent cleaning as well as for occasional repairs, much would be accomplished toward prolonging the life of the boiler.

Because the tubulous boiler is composed of many elements, any one of which can be easily repaired or replaced, is no excuse for trying to prolong its allotted existence, which would simply result in continual annoyance and anxiety from frequent break-downs. As a consequence, it would seem useless to carry any greater relative proportion of duplicate parts for this type of boiler than for any other.

The accompanying table—No. I—gives the results of a number of tests of tubulous and other boilers, for comparison.

This table has been prepared from data of evaporation tests made at different times by boards of United States naval engineers. The locomotive boiler test is an exception, however, it having been made in England on the boilers fitted in the Italian torpedo-boats *Tripoli* and *Folgore*. Although these tests were not strictly comparable, on account of the great disparity in sizes of boilers, ratios of heating to grate surface, and variety of working, they can be taken to fairly represent the comparison intended by the writer: the relative weight and space occupied by the three types of boiler—tubulous, locomotive and Scotch.

In the case of the large Ward boiler, the grate area and

TUBULOUS BOILERS.—TABLE I.

Type.	Dimensions.	Grate Area.	Heating Surface.	Ratio.	Com'n	Evaporation from and at 212° F.				Per cent. Moisture.	Weights.					Air Pressure, Ins. of Water.	Steam Pressure, Lbs.	Coal.
					Per Sq. Ft Grate.	Per Lb. Coal.	Per Lb. Com'ble.	Per Sq. Ft. H. Surface.	Per Cu. Ft. Space.		Empty Lbs.	Steaming Level.	Per I. H. P.	Per Sq. Ft. H. Surface.	Per Lb. Water Evaporated.			
Belleville.	Length, 8'-6" Width, 7-0 Height, 11-0 Space, 654.5 cu. ft.	34.17	804	1 to 23.5	12.8	9.6	10.42	5.2	6.4	6.31	40,670	42,770	204	53.2	10.1	Nat'l.	111	Bit.
Herreshoff.	Length, 4'-9" Width, 3-8 Height, 4-0 Space, 69.6 cu. ft.	9	205 3	1 to 22	9.3 25.8	7.6 7.14	10.23 8.68	3.1 8	9.1 23.8	3.5	2,915	3,050	96 36	14.8	4.8 1 8	Jet. Jet.	120 195	Anth. do.
Towne.	Length, 2'-6" Width, 2-6 Height, 3-3 Space, 20.3 cu. ft.	4.25	75	1 to 17.6	4.3 24.5	10.46 5.6	13.4 6.77	2.7 8.2	10 30.4	....	1,380	1,640	172 56	21.8	8.1 2.6	Nat'l. 1.14	148 152	Anth. do.
Ward.	Diameter, 3'-2" Do., Drum, 1-7 Height, 7-2 Space, 42.7 cu. ft.	3.68	145.8	1 to 39 5	7.9 15.5 62.5	8.59 8.28 6.34	10.77 10 01 7.01	1.7 3.2 10	5.8 11 34.2	....	1,682	1.930	154 82 26	13.2	7.7 4.07 1.3	Nat'l. Jet. Jet.	0 17 161	Anth. do. Bit.
Scotch.	Diameter, 9'-0" Length, 9-0 Space, 572.5 cu. ft.	31.16	727.2	1 to 23 3	24.8 38	8.13 7.87	9.93 9.06	8.6 12.8	11 16.3	3.44 4 29	18,900	30,000	120 80	41.2	4.7 3.1	2.08 4.01	77 78	Anth. do.
Locomotive torpedo.	Length, 16'-8" Width, 6'-4" Height, 7'-6" Space, 630.3 cu. ft.	28	1,116	1 to 39.8	98 3 120.8	6.97 6.62	....	17.1 20.05	30.5 36.2	....	....	34,990	47.7 33.3	31.3	1.8 1.2	3.13 4 95	125 123	Bit. do.
Ward.	Diameter, 10'-3" Do., Drum, 4-6 Height, 11-8 Space, 729.3 cu. ft.	53 66.5	2,473.5 2,490	1 to 46.6 1 to 37.4	55.04	8.03	8.44	9.47	32.1	11.6	26,533	30,474	26	12.3	1.3	2	160	Bit.
Thornycroft. (U. S. S. *Cushing*.)	Length, *10'-0" Width, *7'-0" Height, *8'-0" Space, *560 cu. ft.	38.3	2,375	1 to 62	45	....	....	....	....	....	20,160	24,640	*31	10.3	....	3	245	Bit.

* Approximate.

TABLE NO. II.

	1.	2.	3.	4.	5.
Type of Boiler.	Combustion.	Evaporation per Cu. Ft. of Space.	Weight per I. H. P.	Weight per Sq. Ft. Heating Surface.	Weight per Lb. Water Evaporated.
Belleville	0.50	0.50	2.02	2.10	2.50
Herreshoff..........	1.00	0.95	0.72	0.60	0.90
Towne	1.00	1.20	1.12	0 87	1.30
Scotch..............	1.00	0.44	2.40	1.64	2.30
Locomotive..........	3.90	0.31	3.70	1.25	3.50
Ward	2.20	0.58	1.27	0.50	1.53

heating surface used are given ; the actual areas are added below. The evaporation, apparent in each case, is from and at 212. Where calorimetric tests were made the percentage of moisture is given.

The weight per I.H.P. is estimated on a basis of 20 lbs. of water per hour for all cases excepting the Scotch boiler, where 25 lbs. have been used, as this boiler was limited to 80 lbs. pressure of steam.

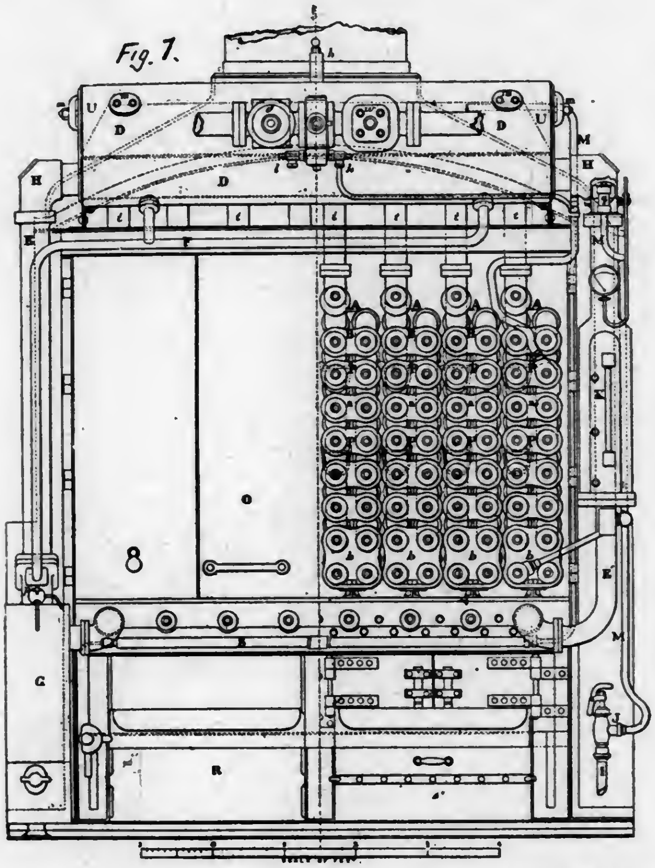
The accompanying approximation, Table II., is made from the large table, on the assumption that the evaporation varies directly as the combustion, and 25 lbs. of coal per square foot of grate per hour used as the unit.

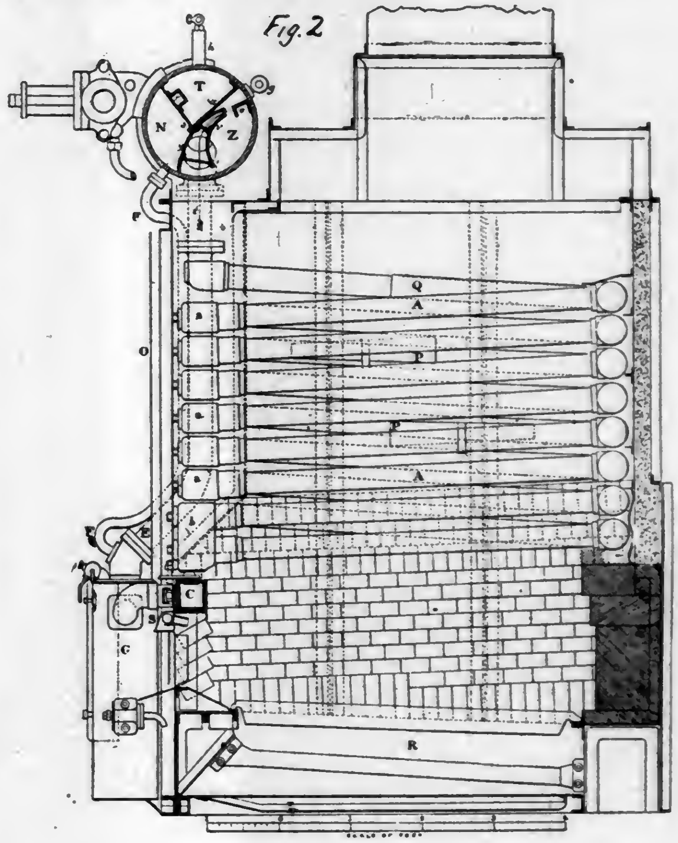
The assumption noted above is manifestly unfair to those boilers using a high rate of combustion ; however, leaving the small Ward boiler out of the comparison, it will be seen that the locomotive boiler is the only one to suffer. The large Ward boiler, although burning 55 lbs. of coal per square foot of grate, has approximately the same evaporation per pound of coal as the others at 25 lbs. These figures, speaking for themselves, need but little comment. The locomotive boiler should receive a favorable correction of about 20 per cent. in columns 2, 3 and 5, on account of the high rate of combustion. On the other hand, the Belleville boiler should receive an adverse correction of about 10 per cent., on account of low combustion ; but even without this correction, it is seen that this boiler has no practical advantage over the Scotch either in space occupied or weight. All the other tubulous boilers given greatly exceed the Scotch in these advantages of weight and space.

THE BELLEVILLE BOILER.

This boiler, as shown in figs. 1 and 2, consists of a system of tubes of equal length joined together by junction boxes of malleable steel, so as to form a series of flat coils, each of which is connected to the feed-water box *C* at the eration and a great convenience in case of repairs. The feed-water box is of iron, forged in rectangular section.

The interior of the drum is divided into three nearly equal compartments, *Z*, *T* and *N*, by diaphragm plates *x*, *y* and *s*, extending its whole length, bent and riveted together along a line near the axis.





THE BELLEVILLE BOILER.

lower end of the coil, and to the steam-drum *D*, at its upper end. The steam drum, into which the feed water is delivered, is connected with the feed-water box and a vertical cylindrical vessel, called a sediment collector, by two outside pipes *E* and *E'*, the one on the starboard end leading direct to the feed-water box. This arrangement permits of a continuous circulation of water and steam through the tubes to the drum, and of the water from the drum to the feed-water box.

The tubes are of lap-welded wrought-iron, 3.9 in. outside diameter. The back junction-boxes are simple U-connections, the lowest of these boxes, *b b*, resting directly on the feed-water box, having each four openings for the reception of tubes, one opening in the lower row being blanked off; the other front junction-boxes, *a a*, form simple horizontal U-connections like those at the back. The lower front junction-boxes have two chambers, the upper one forming a U-connection, and the lower one, which receives the lower end of the last tube, connecting with the water-box. On the front of each front junction-box there are sight holes, closed by wrought-iron plugs, each held in place by a single T-head bolt and nut, the joint being made with linen asbestos cardboard.

Each tubular element, *A A*, is complete in itself and independent. In case of any accident to a tube or tubes of an element, the latter can be readily and quickly disconnected, the connection holes blanked, and the rest of the boiler used without inconvenience. The tubes are screwed into the back junction-boxes with ordinary pipe threads, and further secured by jam-nuts; at the front ends they butt against nipples, threaded similarly to the tubes, and are held in place by screw-couplings, shouldered against the faces of the boxes and secured by jam-nuts on their backs. By this arrangement any two tubes, connecting in the same back junction-box, may be removed and replaced without disturbing any of the others, a valuable consid-

The circulation in this boiler is as follows: Water passes by a pipe *I*, through a graduated check valve *J*, to the feed pipe *M*, thence to an automatic feed regulator *q*, secured to the stand-pipe *K*, and to which is attached the water-gauge glass. From the regulator the water passes, by means of pipe *M* (*g* in side view), to the longitudinal center of the steam-drum *D*, delivering just above the shelf *e*, where it meets the steam delivered into *Z* through *t t*; here it thoroughly mixes with the steam, which is supposed to heat it sufficiently to precipitate the lime salts, which, falling to the bottom of *Z*, are carried along with the water through the pipe *E* to the sediment chamber, and by pipe E^1 to the feed-water box direct.

The water flows from the sediment collector to the feed-water box, which supplies the several series of tubes, the water and steam passing by pipes *t t t* to the chamber *Z* in the drum. The steam escapes through the triangular openings *U* and U^1 into *T*, and thence through the dry-pipe *r* into *N*, from which it passes to the stop valve *w*, or safety valve *d*.

(TO BE CONTINUED.)

Violence and Strikes.

A CONFERENCE was recently held in Belgium of delegates who represented 265,000 unionist miners. It was presided over by Mr. Thomas Burt, M.P. In his speech he said:

"'British unionists were strongly opposed to violence and illegality. Let them regard as their greatest enemies, in whatever guise of friendship they came, those who counselled intimidation, violence and outrage. Such advice was not only imprudent and suicidal, but in a free country it was wicked and criminal in the extreme. Let them trust to the reasonableness of their cause."

With regard to strikes, Mr. Burt said: "He was not prepared to condemn them without qualification. In the last re-

sort a strike was the only weapon available to the workmen; but it was a two edged weapon, that required to be used with skill and discrimination, or it recoiled on the heads of those who used it. Young societies rushed into strikes without thought; they were often defeated, disheartened, disorganized, and placed in a worse position than they were before." Referring to peaceful methods, he said: "In every case they should try conciliation and arbitration as a means of settling their differences. These were the lessons they had learned from experience, and their gains were the result of patient, steady, and persistent agitation, by legal, rational, and constitutional means." He counselled united action, rather than legislative interference with the hours of full-grown men.

In commenting upon this subject the editor of *Engineering* says: "If English labor disputes are severe and prolonged sometimes, they have ceased to be riotous. Self-restraint is the natural offspring of organization."

THE ESSENTIALS OF MECHANICAL DRAWING.

By M. N. Forney.

(*Continued from page 279.*)

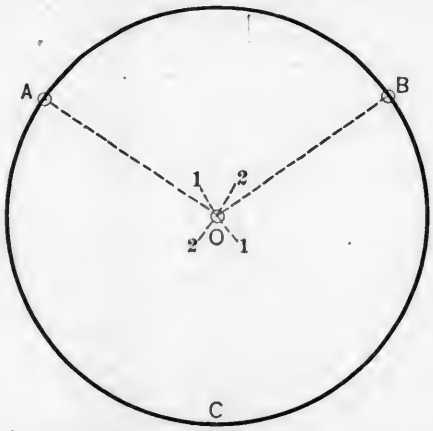
CHAPTER III.—(*Continued.*)

CIRCLES.*

Problem 32 (fig. 77). *To describe a circle or arc of a circle passing through two given points and with a given radius.*

Let *A* and *B* be the two points, and the radius = 2". From *A* and *B* as centers and this distance as a radius describe arcs

Fig. 77.



1 1 and 2 2 intersecting each other in *O*. Then *O* will be the center of the proposed circle from which it can be drawn, and will pass through the points *A* and *B*.

Problem 33 (fig. 78). *To describe a circle whose circumference shall pass through three given points which are not in a straight line.*

Let *A B* and *C* be the three points. Join them by the chords † *A B* and *E C*. Bisect the chords, and through the middle points *D* and *E* draw *F O* and *G O* perpendicular to *A B* and *B C*. The point of intersection, *O*, of these lines will be the center of the proposed circle, which may be drawn from this center with a radius *O A*, so as to pass through the three given points.

Problem 34 (fig. 78). *To find the center and radius of a given circle.*

Let *A B C I* be the given circle. Between any three points, *A B* and *C*, draw chords *A B* and *B C*. Bisect these chords by perpendiculars *F O* and *G O*. Their point of intersection, *O*, will be the center of the circle, and its radius will be *O H* or *O J*.

Problem 35 (fig. 79). *To draw a tangent to a circle* ‡ *at a given point in its circumference.*

Let *A* be the given point in the circumference of the circle. From *A* to the center of the circle draw the radius *A O*.

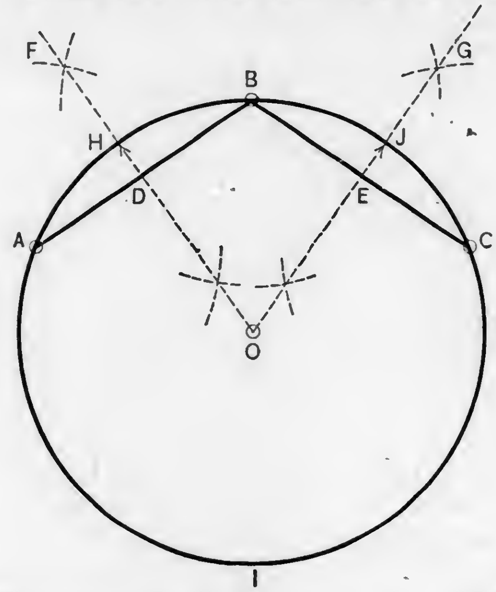


Fig. 78.

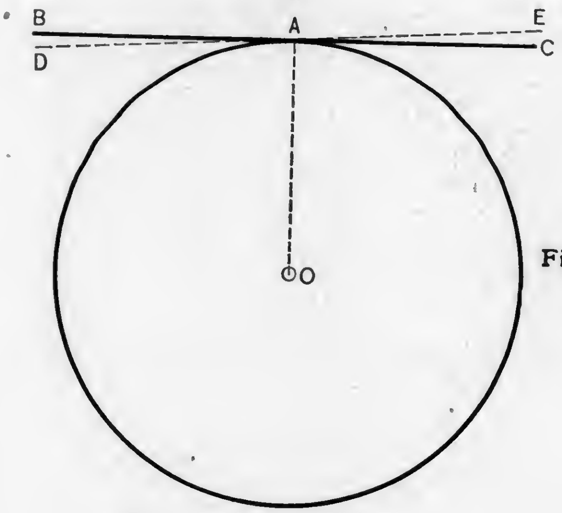


Fig. 79.

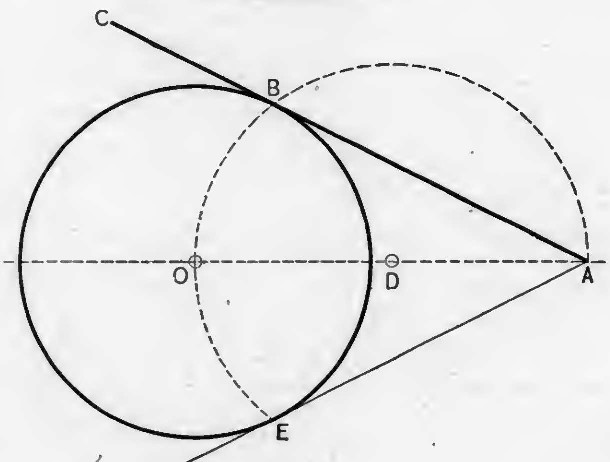


Fig. 80.

Through *A* draw *B C* perpendicular to *A O*. *B C* will then be tangent to the circle at *A*.

Problem 36 (fig. 80). *To draw a tangent to a circle from a given point without the circumference.*

Let *A* be the given point. Join *A* and the center *O* of the circle by the line *A O*. Bisect *A O* at *D*, and from *D* as a center and a radius *D A* or *D O* draw the semicircle *O B A*, cutting the circle in *B*. Through the points *A* and *B* draw

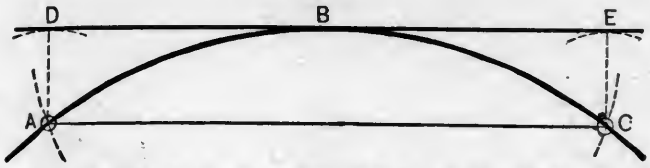
* A circle is defined as "a plane figure bounded by a curved line, every point of which is equally distant from a point within called the *center*." The outside or bounding line is called the *circumference*.

† A *chord* is a straight line joining the extremities of an arc. Thus the straight line *A D B*, fig. 78, is the *chord* of the arc *A H B*.

‡ A line is said to be tangent to a circle when it touches the circle at one point, but does not intersect or cut off any portion of the circumference. A tangent to a circle is always perpendicular or at right angles to the radius drawn from the point at which it touches to the center of the circle. It apparently would be very easy to draw a straight line, *D E*, fig. 79, with a ruler which would touch the circle at the point *A*, but if the line was not perpendicular to a radius drawn through *A*, it would in reality not be tangent to the circle at that point, but to some point on one side of *A*. In drawing it is often important that the position of a tangent should be correct, and therefore it should be drawn perpendicular to the radius at the tangent point.

the line $A\ B\ C$, and it will be tangent to the circle at B. If the semicircle $A\ B\ O$ is extended so as to intersect the circle at

Fig. 81.



E, and the line $A\ E\ F$ is drawn, it will also be tangent to the circle at the point E.

PROBLEM 37 (fig. 81). *To draw a tangent to an arc of a circle, passing through a given point in the arc, when the center is not accessible.*

Let $A\ B\ C$ be the arc and B the point upon the arc at which the tangent is to be drawn. Lay off equal distances $B\ A$ and

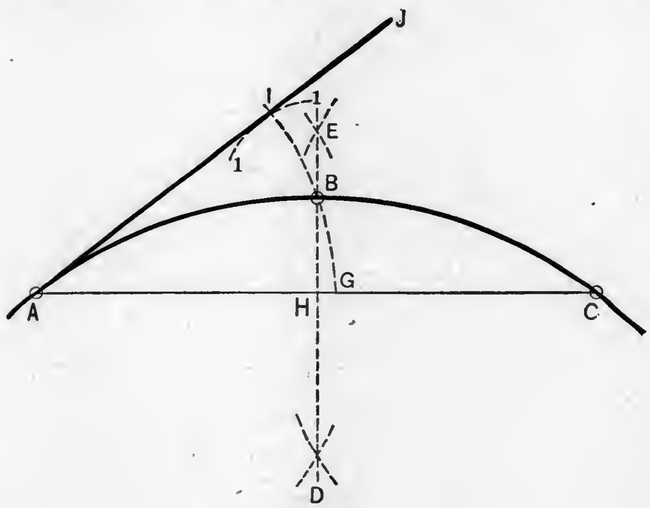


Fig. 82.

$B\ C$ upon the arc from B to A and C. Join A and C by the line $A\ C$. Then through B draw a line $D\ B\ E$ parallel to $A\ C$, and it will be tangent to the arc at B.

PROBLEM 38 (fig. 82). *To draw a tangent to an arc passing through a given point in the arc when the preceding method is not applicable.*

Let $A\ B\ C$, fig. 82, be the arc and A the tangent point. From A draw any chord $A\ C$. Bisect it by the line $D\ E$ by Problem 5.

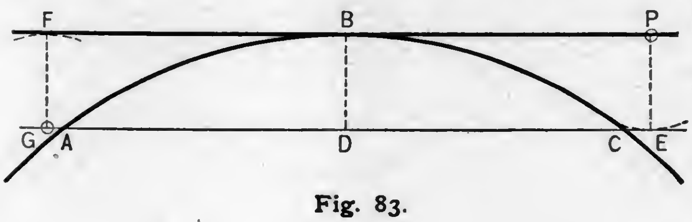


Fig. 83.

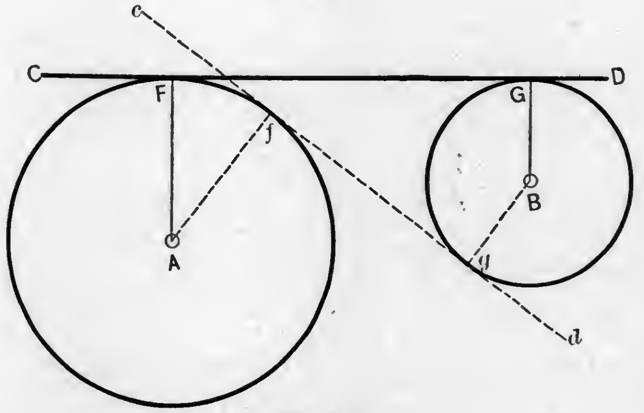


Fig. 84.

From A as a center and $A\ B$ as a radius draw the arc $I\ G$. From B as a center and with $B\ G$ as a radius draw an arc 1 1, cutting $I\ G$ at I. Through A and I draw the line $A\ I\ J$, and it will be the required tangent.

PROBLEM 39 (fig. 83). *To draw a tangent to an arc of a circle from a given point without the arc, the center not being accessible.*

Let $A\ B\ C$ be the arc and P the given point. From P draw the line $P\ B\ F$ touching the arc. To ascertain the true tangent point at any convenient distance from $P\ B$, as $P\ E$, draw $E\ D\ G$ parallel to $P\ B\ F$, and cutting the arc at C and A. Bisect the chord $A\ D\ C$ at D, and from D erect a perpendicular $D\ B$, cutting the arc at B; then will B be the true tangent point of $F\ B\ P$ to the arc.

PROBLEM 40 (fig. 84). *To draw a tangent to two given circles.*

Let A and B be the two circles. Draw the line $C\ D$ so as to touch both of them. To ascertain the true tangent points,

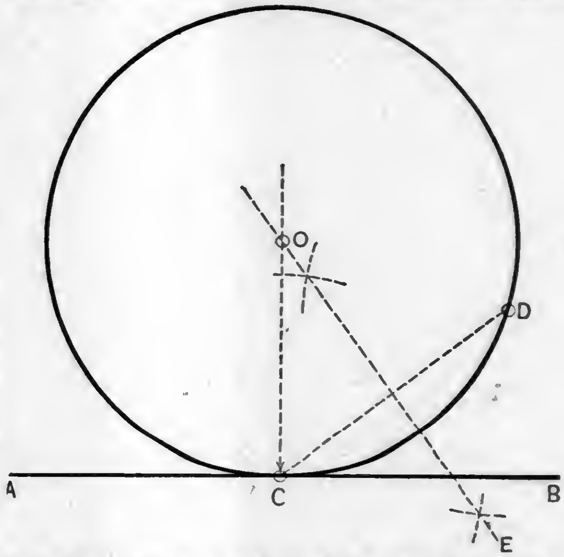


Fig. 85.

from the centers A and B of the two circles draw $A\ F$ and $B\ G$ perpendicular to $C\ D$. F and G will then be the points required.

The same method may be adopted if the tangent should be required to pass between the two circles, as represented by the dotted line $c\ d$. Lines $A\ f$ and $B\ g$ drawn perpendicular to $c\ d$ and through A and B will give the true tangent points, f and g.

PROBLEM 41 (fig. 85). *To draw a circle tangent to a given line $A\ B$ at a given point C in it, and which shall also pass through a fixed point D without the line.*

If C be the point in the line $A\ C\ B$ and D the point without the line, from C draw $C\ O$ perpendicular to $A\ C\ B$. Join C and

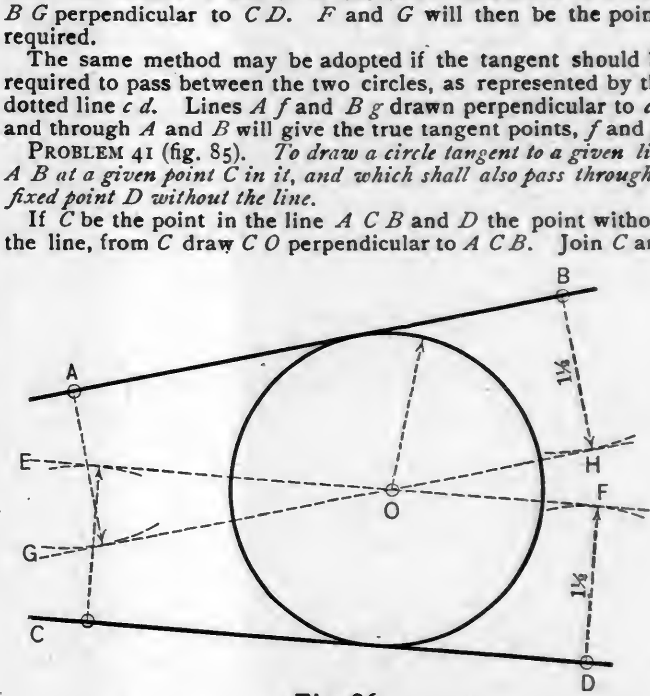


Fig. 86.

D by a line $C\ D$, and draw a perpendicular $O\ E$ bisecting $C\ D$ and intersecting $C\ O$ in O. O will then be the center of the required circle, which may be drawn from it with a radius $O\ C$ so as to be tangent to $A\ C\ B$ at C and also pass through D.

PROBLEM 42 (fig. 86). *To draw a circle of a given radius tangent to two given inclined lines, $A\ B$ and $C\ D$.*

If $A\ B$ and $C\ D$ be the two inclined lines, and the radius of the circle $= 1\frac{1}{4}''$, then by Problem 3 draw lines $E\ F$ and $G\ H$ parallel to $A\ B$ and $C\ D$, and at a distance, $B\ H$ and $F\ D$, from them = the radius of the circle. The point of intersection, O, of these lines will be the center of the circle from which it may be drawn with the given radius.

PROBLEM 43 (fig. 87). *To draw a circle that shall touch two straight lines, $A\ B$ and $A\ C$, which are inclined to each other, the circle to be tangent to one of the lines in a given point.*

If $A\ B$ and $A\ C$ be two inclined lines, which meet in the vertex A, and P be the given point, bisect the angle $B\ A\ C$

by a line *A D*. From *P* draw a line *P O* perpendicular to *A C*. Then the intersection *O* of *A D* and *P O* will be the center of the circle, which may be drawn with the radius *O P*.

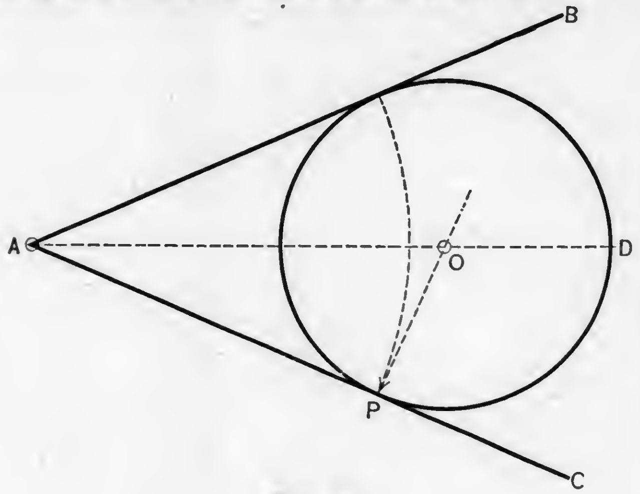


Fig. 87.

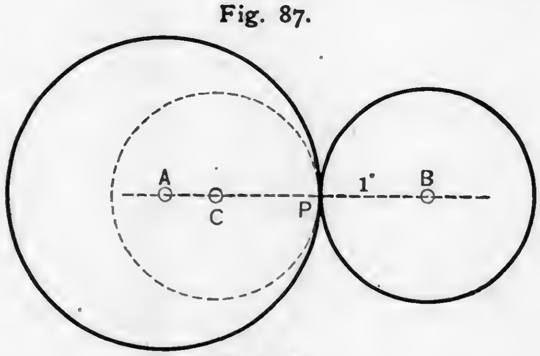


Fig. 88.

PROBLEM 44 (fig. 88). *To describe a circle B of a given radius, touching another given circle A at a given point P.*

If *A* be the given circle, *P* the given point, and the given radius = 1", from *A*, the center of the given circle, draw a straight line *A P* through *P*. If the two circles are to be out-

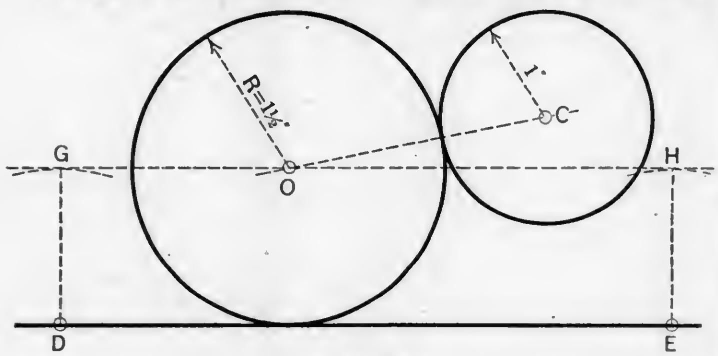


Fig. 89.

side of each other, extend *A P* beyond *P*. From *P* lay off a distance *P B* = to the given radius. From *B* as a center and with the given radius describe the circle as required.

If the circle required must be inside of the given circle, then from *P* lay off a distance *P C* toward the center *A* = to the given radius. *C* will then be the center of the required circle, which may be drawn from it with the given radius.

PROBLEM 45 (fig. 89). *To draw a circle O of a given radius, which shall be tangent to a given circle C, and also tangent to a straight line D E.*

If the radius *R* of the circle is $1\frac{1}{2}$ in., draw *G H* parallel to *D E* at a distance $D G = R = 1\frac{1}{2}''$. If the radius of $C = 1''$, then with *C* as a center and the sum of the two radii—that is, $1\frac{1}{2}'' + 1'' = 2\frac{1}{2}''$—draw an arc intersecting *G H* in *O*. Then *O* will be the center from which the circle may be drawn with a radius = $1\frac{1}{2}''$, which will be tangent to *C* and to *D E*.*

PROBLEM 46 (fig. 90). *To describe with given radii two circles, O and C, touching each other, and also a given line A B.*

Let *A B* be the given line, and the radii of the circles = $1\frac{1}{2}''$ and 1". From any point *E* on *A B* draw *E O* perpendicular to *A B*, and from *E* lay off a distance *E O* equal to $1\frac{1}{2}''$ the greater radius. From *O* as a center and $1\frac{1}{2}''$ as a radius draw the larger

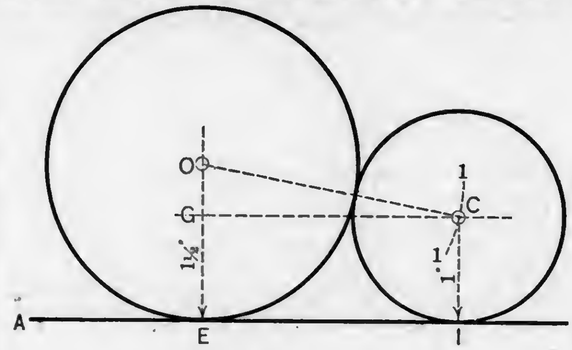


Fig. 90.

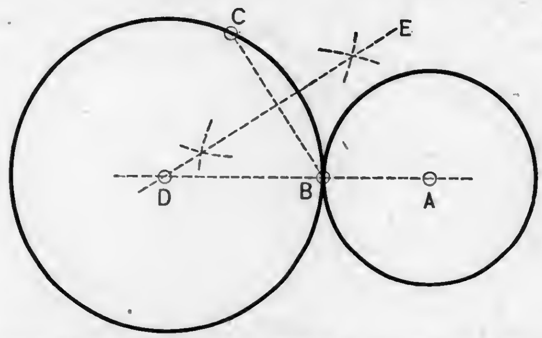


Fig. 91.

circle. From *E* lay off a distance *E G* = to the smaller radius, or 1", and through *G* draw *G C* parallel to *A B*. Then from *O* as a center and the sum of the radii, or $1\frac{1}{2}'' + 1'' = 2\frac{1}{2}''$ as a radius, draw the arc 1 1 cutting *G C* in *C*. *C* will then be the center of the second circle, which, when drawn with a radius of 1", will be tangent to the larger circle and to the line *A B*.

PROBLEM 47 (fig. 91). *To draw a circle through a point C and tangent to a given circle A at a given point B in its circumference.*

If *A* be the given circle, *B* the tangent point, and *C* the given point without the circle *A*, through the center *A* and the tangent point *B* draw a straight line *A B* and extend it toward

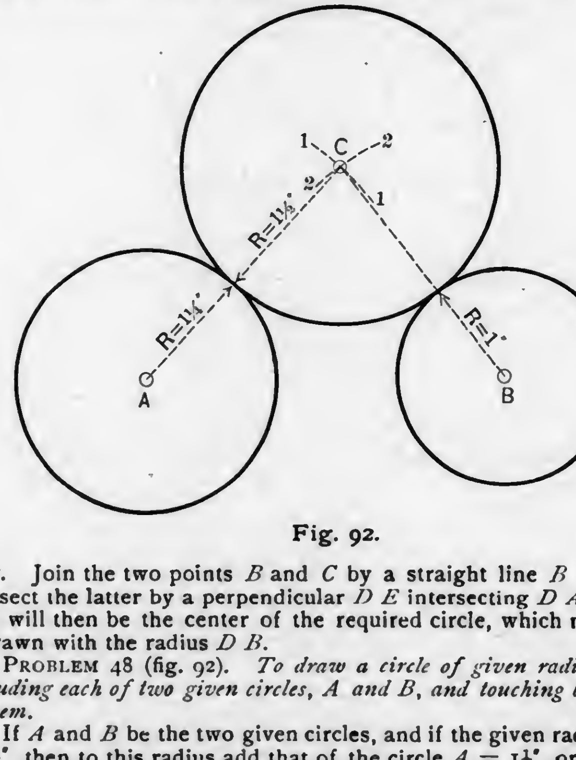


Fig. 92.

D. Join the two points *B* and *C* by a straight line *B C*, and bisect the latter by a perpendicular *D E* intersecting *D A* at *D*. *D* will then be the center of the required circle, which may be drawn with the radius *D B*.

PROBLEM 48 (fig. 92). *To draw a circle of given radius, excluding each of two given circles, A and B, and touching both of them.*

If *A* and *B* be the two given circles, and if the given radius = $1\frac{1}{2}''$, then to this radius add that of the circle $A = 1\frac{1}{4}''$, or $1\frac{1}{2}'' + 1\frac{1}{4}'' = 2\frac{3}{4}''$. With this sum as a radius, from *A* as a center draw an arc 1 1; then add the radius of the circle $B = 1''$ to the given radius, or $1\frac{1}{2} + 1 = 2\frac{1}{2}''$, and with this sum as a radius and *B* as a center describe an arc 2 2 intersecting 1 1 at *C*. This will be the center of the required circle, which may be drawn with the given radius $1\frac{1}{2}''$.

PROBLEM 49 (fig. 93). *To draw a circle of a given radius, in-*

* If two circles are tangent to each other, a straight line connecting the centers of the circles passes through their tangent point. It is often important to locate this point precisely.

cluding each of two given circles A and B, and touching both of them.

If A and B be the two given circles, whose radii are $1''$ and $\frac{3}{4}''$ respectively, and the given radius be $2\frac{1}{4}''$, from the latter deduct the radius of A, or $2\frac{1}{4} - 1 = 1\frac{1}{4}''$. With this remainder as a radius and from A as a center describe an arc 1 1. Then

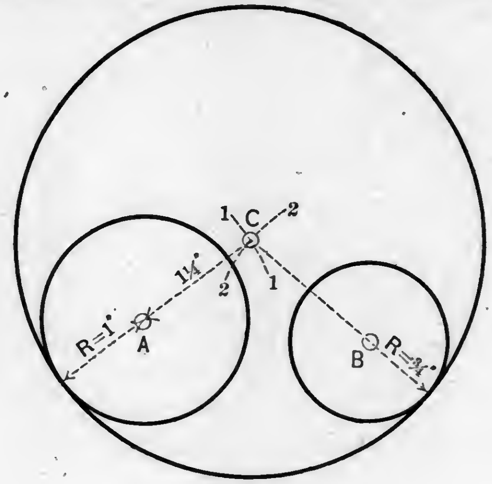


Fig. 93.

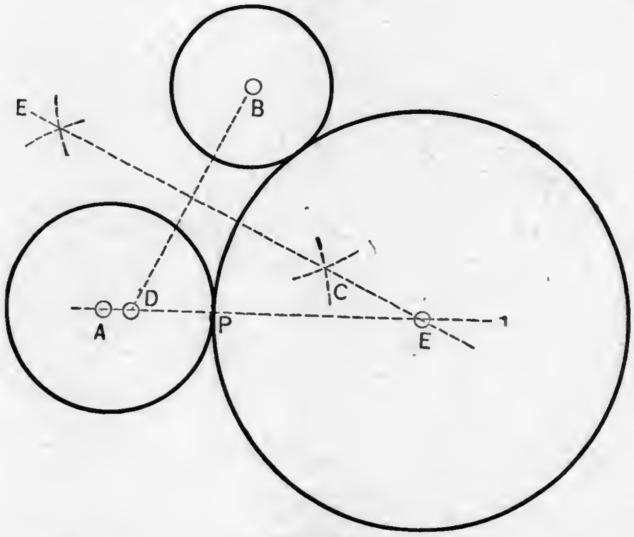


Fig. 94.

from the given radius, $2\frac{1}{4}''$, deduct the radius of $B = \frac{3}{4}''$, or $2\frac{1}{4} - \frac{3}{4} = 1\frac{1}{2}''$. With this remainder as a radius and B as a center describe an arc 2 2 intersecting 1 1 at C; this will be the center of the required circle, which can be drawn with the given radius of $2\frac{1}{4}''$ so as to touch and include the circles A and B.

Problem 50 (fig. 94). *To describe a circle touching each of two given circles, A and B, externally, and also one at a given point P.*

If A and B be the centers of the given circles, and P the given point, from the center A draw the radius $A\ P$ through P and extend it. From the given point P set off, on the radius $A\ P$, a distance $P\ D$ equal to the radius of the other given circle B. Join the points B and D by a line $B\ D$, and bisect it with a perpendicular $C\ E$, and extend it until it intersects $B\ P\ E$ at E. E will then be the center of the required circle, which may be drawn with a radius $E\ P$.

Problem 51 (fig. 95). *To describe a circle about a given triangle, A B C.*

If $A\ B\ C$ be the given triangle, bisect any two sides, as $A\ B$ and $A\ C$, by the perpendiculars $g\ h$ and $e\ f$, intersecting each other in the point D. From D as a center and $D\ A$ as a radius the required circle may be drawn.

Problem 52 (fig. 96). *To inscribe a circle in a given triangle, A B C.*

If $A\ B\ C$ be the given triangle, bisect any two of the angles —as $A\ B\ C$ and $C\ A\ B$—by the straight lines $A\ D$ and $B\ D$ intersecting in the point D. From D draw a perpendicular, $D\ E$, to any side, as $A\ B$. Then with D as a center and $D\ E$ as a radius describe a circle which will touch the three sides of the triangle.

Problem 53 (fig. 97). *To inscribe in an equilateral triangle, A B C, the three largest triangles which it will contain, and which will be tangent to each other and to the sides of the triangle.*

If $A\ B\ C$ be the triangle, draw $A\ G$, $B\ F$ and $C\ E$, bisecting the angles and sides of the triangle, and intersecting each

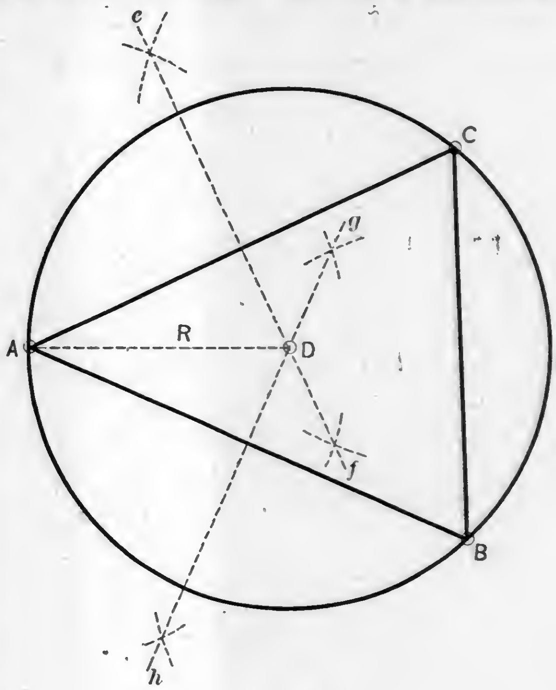


Fig. 95.

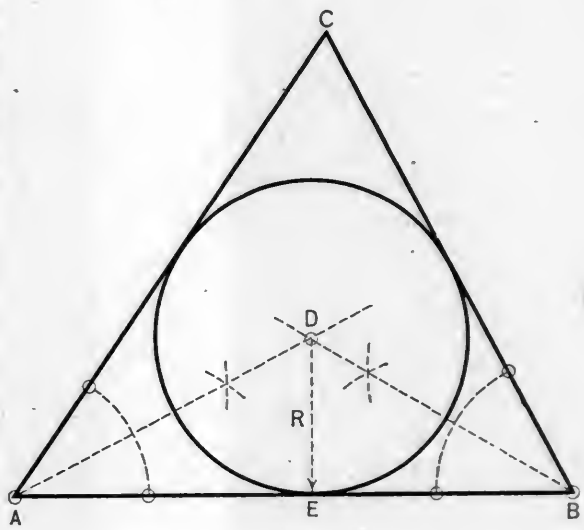


Fig. 96.

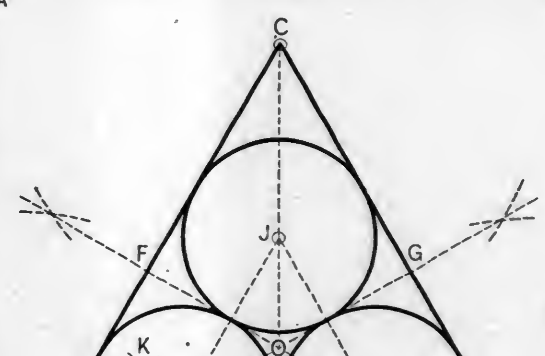


Fig. 97.

other in O. Bisect the right angle $A\ E\ O$ by a line $E\ K$. Through H, the point of intersection of $E\ K$ with $A\ O$, draw

$H L$ parallel with $A B$, $H J$ parallel with $A C$, and join the points of intersection of $H L$ and $H J$ with $B F$ and $C E$ by a line $J D$ parallel with $C B$. From H, J and D as centers and

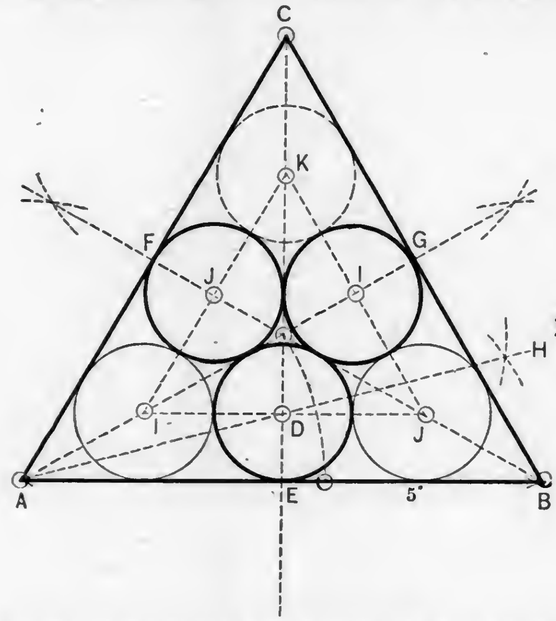


Fig. 98.

$H L$ as a radius draw the three circles, each of which will touch the other two and the sides of the triangle.

PROBLEM 54 (fig. 98). *Within an equilateral triangle, $A B C$, to draw three equal circles, each touching two others and one side of the triangle.*

Bisect the angles $A B$ and C as in the preceding problem. Then bisect the angle $G A B$ by a line $A H$, intersecting $C E$ at D. D will be the center of one of the required circles.

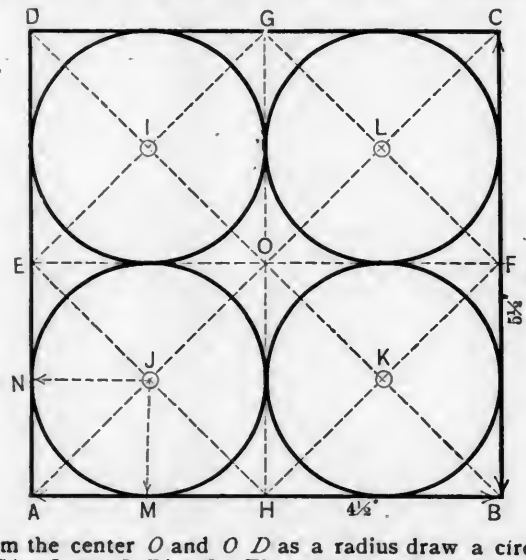


Fig. 99.

From the center O and $O D$ as a radius draw a circle cutting $A G$ in I and $B F$ in J. These points of intersection will be the centers of the required circles, which may be drawn with a radius $D E$.

PROBLEM 55 (fig. 98). *Within an equilateral triangle, $A B C$, to inscribe six equal circles which shall touch each other and be tangent to the sides of the triangle.*

Draw the diagram as for the preceding problem. Then through D draw $I J$ parallel to $A B$, and through J draw $J K$ parallel to $A C$, and through I, $I J K$ parallel to $A C$. I, J and K, the intersections of these lines with each other, will be the centers of three more circles, which, if drawn with the radius $D E$, will be tangent to their adjacent circles and sides of the triangles.

PROBLEM 56 (fig. 99). *To draw in a given square, $A B C D$, the three largest equal circles it will contain, and which will be tangent to the adjacent circles and sides of the square.*

If $A B C D$ be the given square, draw the diagonals $A C$ and $B D$ and the diameters $E F$ and $G H$. Draw diagonals $E H$, $H F$, $F G$ and $G E$ through the small squares into which the larger one has been divided by the diameters. Then $I J K$ and L will be the centers of the required circles, which may be drawn with a radius $J M$ or $J N$.

PROBLEM 57 (fig. 100). *Within a given square, $A B C D$, to draw four equal circles, each touching two others and tangent to the middle of the side of the square.*

Draw the diagonals $A C$ and $B D$ and the diameters $E F$ and $G H$, as in the preceding problem. Bisect the angle $O A B$

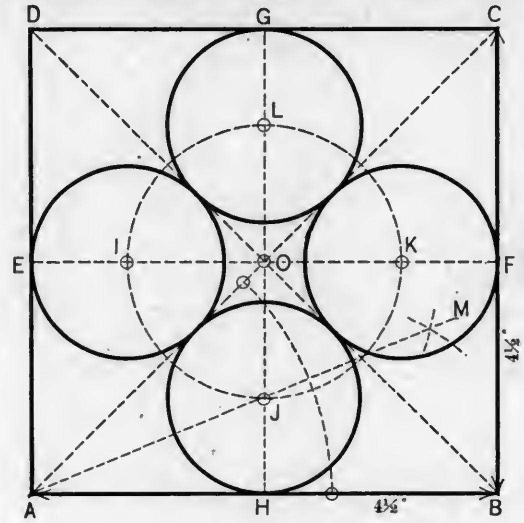


Fig. 100.

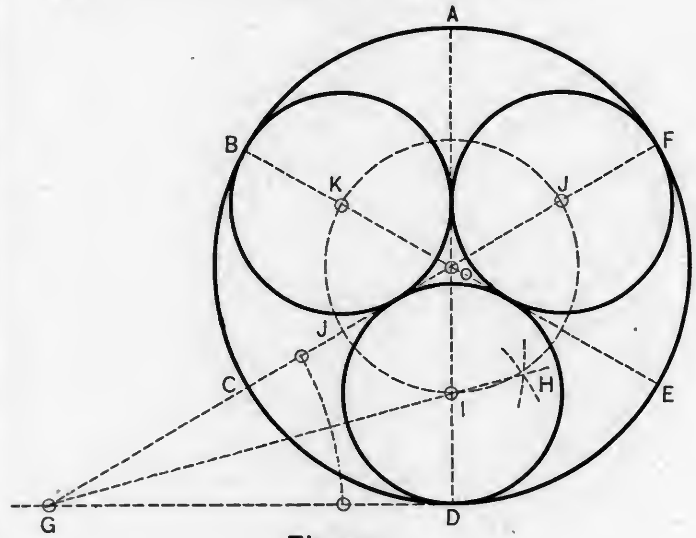


Fig. 101.

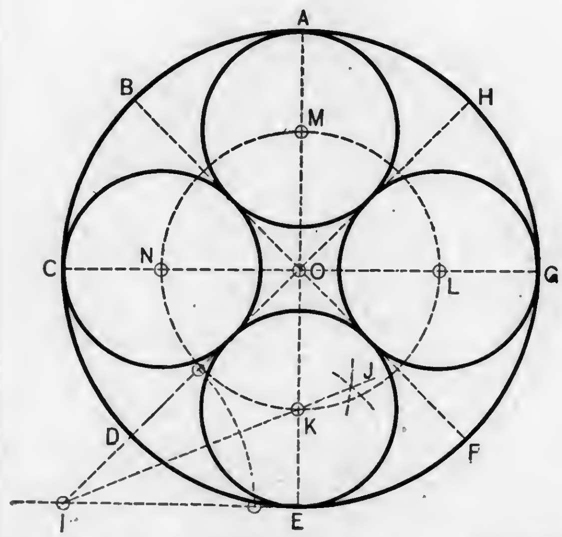


Fig. 102.

by the line $A M$, cutting $G H$ in J. With a radius $O J$ and center O draw a circle $J K L I$ cutting the diameter in the points J, K, L and I, which will be the required centers of the circles which may be drawn with the radius $J H$.

PROBLEM 58 (fig. 101). *To draw three equal circles, $I J K$, in a given circle $A E C$, which touch each other and the given circle.*

With the radius of the given circle divide its circumference into six equal parts, $A B$, $B C$, $C D$, $D E$, $E F$ and $F A$. Through the opposite points of division and the center O of the

circle draw diameters $A\ D$, $F\ C$ and $B\ E$. From any of the points of division, as D, where one of the inner circles should touch the given circle, draw a tangent $G\ D$ and extend an adjacent diameter $F\ C$ to cut $G\ D$ at G. Bisect the angle $O\ G\ D$

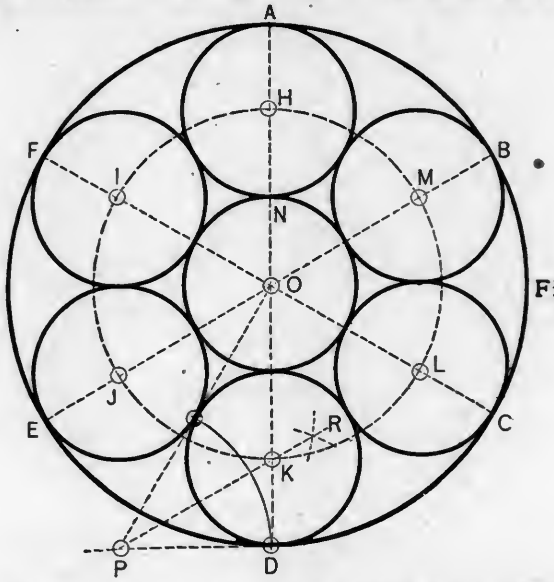


Fig. 103.

by the line $G\ H$. The point of intersection, I, where $G\ H$ crosses $A\ D$, will be the center of one of the inner circles, which may be drawn with a radius $I\ D$. From the center O, with a radius $O\ I$, draw the circle $I\ J\ K$, and where it intersects, the diameters $C\ F$ and $B\ E$ will be the centers of the other two circles.

PROBLEM 59 (fig. 102). *To draw four equal circles, $M\ N\ K\ L$, in a given circle, $A\ C\ E\ G$, each touching two others and the containing circle.*

Divide the circumference, $A\ C\ E\ G$, into eight equal parts, and draw diameters $A\ E$, $B\ F$, $C\ G$ and $D\ H$ through the opposite points of division. From E draw a tangent $E\ I$ to the given circle, and extend $D\ H$ so as to intersect $E\ I$ at I. Bisect

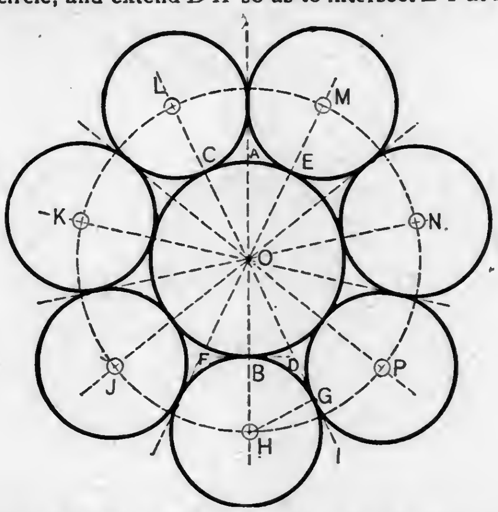


Fig. 104.

the angle $O\ I\ E$ by a line $I\ J$. The point K, where $I\ J$ crosses $O\ E$, will be the center of one of the containea circles, which may be drawn with a radius $K\ E$. From O as a center and $O\ K$ as a radius draw through K the circle $K\ N\ M\ L$, and N, M and L will be the centers of the other circles.

PROBLEM 60 (fig. 103). *To draw seven equal circles, H, I, J, K, L, M, O, in a given circle, $A\ B\ C\ D\ E\ F$.*

Let $A\ B\ C\ D\ E\ F$ be the given circle. With its radius divide the circumference into six equal parts, and through the opposite points of division draw diameters $A\ D$, $F\ C$ and $B\ E$. Divide one of the radii, as $O\ A$, into three equal parts—viz., $O\ N$, $N\ H$ and $H\ A$. From O, with a radius $O\ N$, draw the central circle, and from H as a center, and the same radius, draw the circle $A\ N$. From O as a center and $O\ H$ as a radius draw a circle which, cutting the radii, will give the points I, J, K, L, M. From these points, with a radius $= O\ N$, draw the other circles, each of which will touch the outside circle, two adjoining others, and the central circle.

PROBLEM 61 (fig. 103). *To draw any number of equal circles in a given circle tangent to each other and the given circle.*

Divide the circumference of the given circle, $A\ B\ C\ D\ E\ F$, into as many equal parts as there are circles to be inscribed, and draw diameters through the opposite points of division. From the extremity of one of these diameters, as $A\ D$, draw a tangent $P\ D$. Bisect the adjacent arc $D\ E$ by a line $O\ P$, and extend it so as to cut $D\ P$ in P. Then bisect the angle $D\ P\ O$ by a line $P\ R$. The point K where it intersects $O\ D$ will be

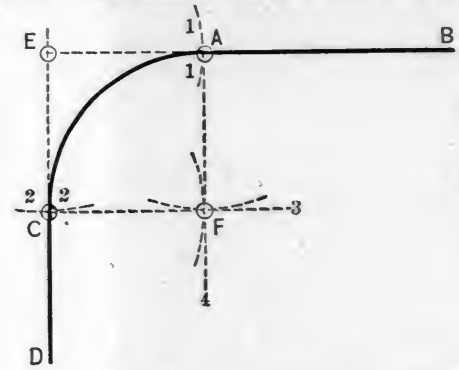


Fig. 105.

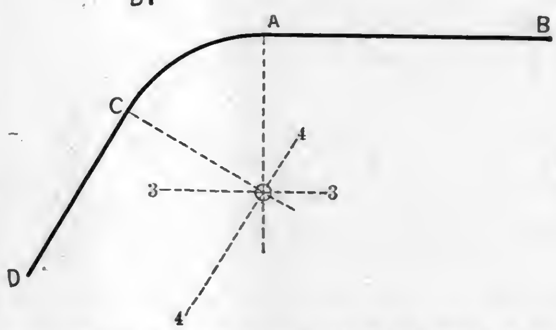


Fig. 106.

the center of one of the circles, which may be drawn with a radius $K\ D$. From the center O, with a radius $O\ K$, draw a circle $H\ I\ J\ K\ L\ M$. The points of intersection, L, M, H, I, J, with the diameters, will be the centers of the other contained circles, which may be drawn with the radius $K\ O$.

PROBLEM 62 (fig. 104). *To draw any number of equal circles about a given circle, O, tangent to each other and the given circle.*

Let O be the given circle about which say seven equal circles are to be drawn, all tangent to O and to each other. Divide the circumference of O into twice as many parts as there are circles to be drawn, and draw diameters $A\ B$, $C\ D$, $E\ F$, etc., through the center O and the opposite points of division. From the extremity B of any diameter draw a tangent $F\ B\ D$, and extend the diameter $C\ D$ to I. From D, the point of intersec-

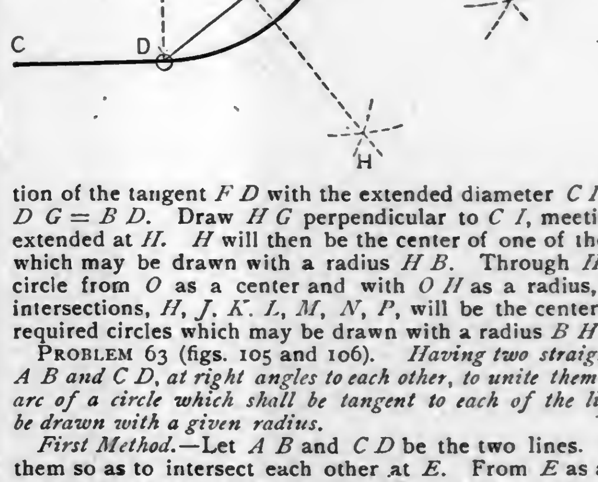


Fig. 107.

tion of the tangent $F\ D$ with the extended diameter $C\ I$, lay off $D\ G = B\ D$. Draw $H\ G$ perpendicular to $C\ I$, meeting $O\ B$ extended at H. H will then be the center of one of the circles which may be drawn with a radius $H\ B$. Through H draw a circle from O as a center and with $O\ H$ as a radius, and its intersections, H, J, K, L, M, N, P, will be the centers of the required circles which may be drawn with a radius $B\ H$.

PROBLEM 63 (figs. 105 and 106). *Having two straight lines, $A\ B$ and $C\ D$, at right angles to each other, to unite them with an arc of a circle which shall be tangent to each of the lines and be drawn with a given radius.*

First Method.—Let $A\ B$ and $C\ D$ be the two lines. Extend them so as to intersect each other at E. From E as a center and the given radius, say $1\frac{1}{2}$", describe arcs 1 1 and 2 2 intersecting $A\ B$ and $C\ D$ at A and C. With A and C as centers,

and the same radius, draw arcs intersecting each other at F, which will be the center from which the required arc $A\ C$ may be drawn with the given radius.

Second Method.—Draw C 3 and A 4 parallel to $A\ B$ and $C\ D$ at a distance from them = to the given radius, or 1¼". The point of intersection F of these lines will be the centers from which the required arc, $A\ C$, can be drawn with the given radius. This method can be employed if the lines $A\ B$ and $C\ D$ are not parallel, as shown in fig. 106.

PROBLEM 64 (fig. 107). *To draw two arcs of circles, which shall be tangent to two parallel straight lines, A B and C D, at given points A and D, and which shall pass through a line D A, meeting the tangent points at any place, E, in that line, and be tangent to each other.*

If $A\ B$ and $C\ D$ be the two parallel lines, A and D the given points in these lines, and $A\ D$ a line meeting these points, and E the place in that line through which the arcs must pass, from A draw $A\ F$ perpendicular to $A\ B$, and from D draw $D\ G$ perpendicular to $D\ C$. Bisect $E\ A$ by a perpendicular $I\ F$ and $D\ E$ by a perpendicular $G\ H$. Then the intersections F and G of these perpendiculars will be the centers of the arcs which may be drawn with radii $F\ A$ and $G\ D$.

(TO BE CONTINUED.)

Recent Patents.

I.—MANUFACTURE OF EYE-BARS.

THE accompanying illustrations, figs. 1–8, show a method of manufacturing eye-bars devised by George M. Heller, of Philadelphia, and covered by Patent No. 424,783, recently issued.

In the drawings, fig. 1 shows a finished eye-bar ; fig. 2, a plain blank bar ; fig. 3, a plain blank bar with a strengthening-loop

FIG. 1.

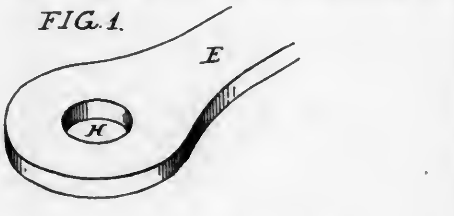


FIG. 2.

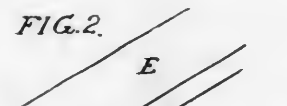


FIG. 3

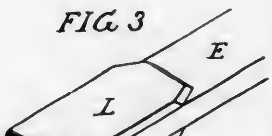


FIG. 4.

FIG. 5.

FIG. 7.

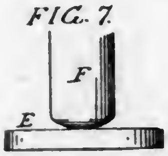
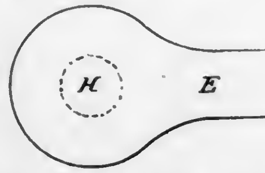


FIG. 6.

FIG. 8.



placed on the end where the head of the eye-bar is to be formed ; fig. 4, the strengthening-loop detached from the bar with its ends properly scarfed ; fig. 5, a blank eye-bar previous to having the pin-hole formed ; figs. 6, 7 and 8 are diagrams showing the manner of forming the pin-hole.

A plain bar E, fig. 3, whose fiber is parallel throughout its length, has a loop L placed on the end of the bar where the head of the bar is to be formed, the fiber of the loop being parallel to the fiber of the bar and also continuous throughout its length, and embracing both faces of the bar E. This disposition of the additional metal in the loop L required to form the head of the bar is chosen because of its providing a large welding surface between the bar and the loop, and it is made to embrace both faces of the bar, thereby making the metal to strengthen the head in a central and equalizing manner. The bar E, with the loop L placed upon it, as shown in fig. 3, is then heated to a welding heat and forged in a properly formed die, thus making a blank eye-bar (shown in fig. 5), the pin-hole of which is formed as in fig. 6, where the opening H for the pin P is made by forcing a plunger F, suitably formed, into the blank eye-bar while it is at a welding heat, thus allowing the plunger F in its advance into the bar to displace the metal of the bar at the pin-hole in a radial manner without severing the fibers, and thereby preserving the original metal of the bar in the neighborhood of the pin and causing the fibers of the finished bar to be arranged in the most proper manner for strength and security.

The method described above is applicable in cases where iron is the metal used. When the bar and loops are constructed of steel, a wrought-iron plate of proper shape to facilitate the welding of the steel together is inserted between the faces of the bar and loop. In some cases wrought-iron loops may be applied directly to steel bar, or steel loops may be applied directly to an iron bar, without departing from the invention.

II.—JOURNAL-BOX.

Figs. 9, 10 and 11 show a form of journal-box and bushing covered by Patent No. 425,569, recently issued to Thomas Gare, of Stockport, England.

Fig. 9 is a sectional end view of the bush and bearing. Fig. 10 is a longitudinal section of the bearing, showing the bush partly in section and partly in view. Fig 11 is a side elevation of the bush detached.

The bush a consists of a flat metal bar coiled into a hollow cylinder and inserted in the box $b\ b$, which is furnished with a

Fig. 9.

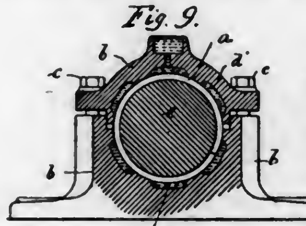


Fig. 10.

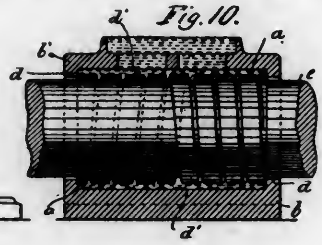
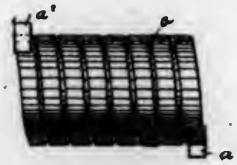


Fig 11.



cap b' in such a manner that when pressure is exerted on the bush a by means of the bolts c and cap b' it will be prevented from revolving and will contract cylindrically, so as to permit of compensating for the wear that takes place from time to time, the bush a being held in position longitudinally by means of the flanges d, formed at each end of the bearing and cap b and b'.

In order to insure a proper fit of the bush a when new, without applying pressure thereon, the interior diameter is made a little less than the diameter of the shaft e, to which it will be applied.

On the sides of the bush a one or more cavities d' are formed in the bearing $b\ b'$, which serve as receptacles for the lubricant, whence it supplies itself to the interior of the bush a by passing between the coils of the same.

The arms or lugs $a^1\ a^2$ may be provided with set-screws by which the bush may be contracted or expanded to insure a proper fit.

III.—CAR-HEATING APPARATUS.

Figs. 12, 13 and 14 show an improvement in car-heating apparatus invented and patented by William Buchanan, of New York, the patent being No. 424,459. Fig. 12 is a bottom view of the ends of two cars with the invention attached ; fig. 13 is a side view, and fig. 14 is a perspective view.

This is a joint or coupling for a continuous heating apparatus, and is intended to complete the connection between the cars. In the cuts A and B are the sills of the two cars and b the buffers. The main lines of steam pipe are shown at C and D. At E is a swivel-joint, e is a pipe extending down from it ; G is a cross

pipe, which is attached by a coupling to a ball-and-socket joint at *K*. The latter carries the connecting pipe *M* which terminates in the coupling *O*, which connects to the similar coupling on the adjoining car, as shown. The general action will be readily understood from the engravings.

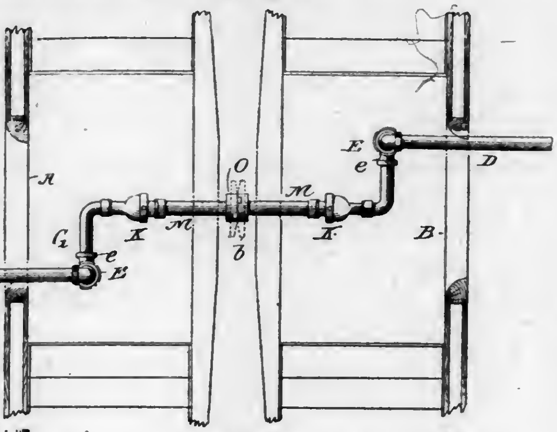


Fig 12

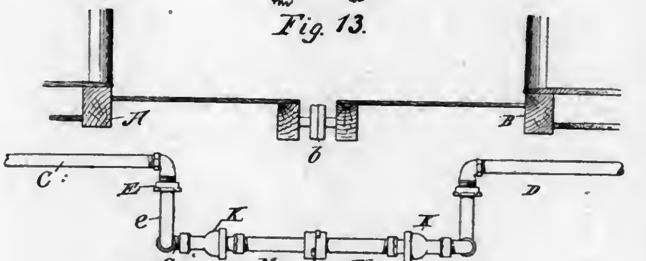


Fig. 13.

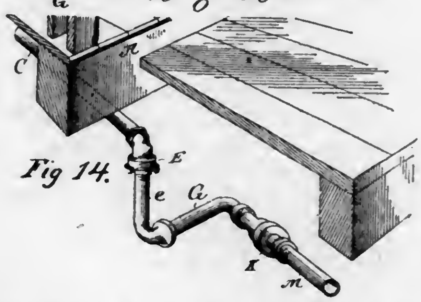


Fig 14.

The inventor says : " It will be observed that the swivel-joint mechanism is arranged vertically, the cross-pipe is at right angles and placed horizontally, and the ball-and-socket-joint mechanism is at right angles to the cross-pipe, but is preferably

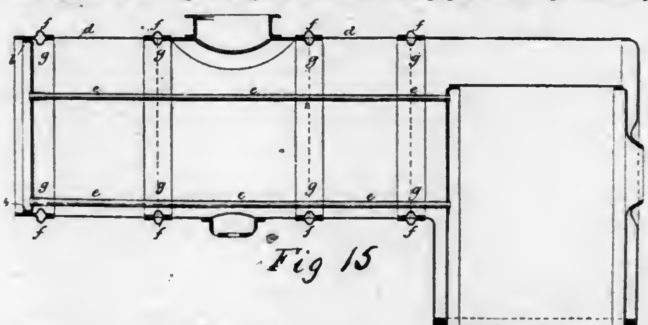


Fig 15

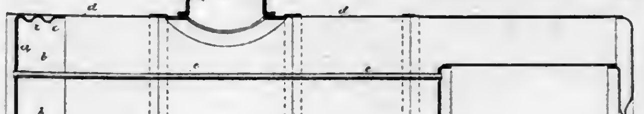


Fig. 16.

in the same horizontal plane. By reason of the ball-and-socket-joint mechanism the connecting-pipe *M* can be adjusted at any desired angle. so that its coupling can be attached to the one of the other car without difficulty, and when the cars are in motion the coupling-pipe can assume all necessary angles. The motion between the cars, due to their approaching and receding from one another, is allowed for by the swivel-joint and the cross-pipe *G*. As the cars approach, the swivel-joint comes into play, the cross-pipe moves in an arc, and the motion of the car is thus allowed for. As the cars recede, the same thing takes place, only the cross-pipe moves in the opposite direction.

" It will be seen that the swivel-joint mechanism supports the cross-pipe and the ball-and-socket-joint mechanism without requiring special supports for these parts from the car-body, which is a difficult matter to accomplish. When the cars are separated, the only part of the apparatus which hangs down toward the ground is the connecting-pipe *M*, and this cannot drop to any great extent.

" The gist of the invention lies in allowing for all the various motions using a swivel-joint and a ball-and-socket joint, the swivel-joint being so related to the rest of the apparatus that it supports and carries the pipes and connections between itself and the coupling *O*. A ball-and-socket joint in place of the swivel-joint would allow for all the movements ; but when the cars were separated the parts would not be held positively, and some of them would fall toward the ground. Thus a ball-and-socket joint would not be the equivalent for the swivel-joint here shown if it occupied the same position in the combination.

" I am well aware that both ball-and-socket joints and swivel-joints are old ; but I believe myself to be the first to so arrange them under a car that all the necessary motion can be made by the coupling. When the cars are uncoupled, the swivel-joint supports all the parts between itself and the coupling. In this way the attendant in coupling the cars has only to lift the coupling-pipes, and, if necessary, to turn the swivel-joint to effect the union."

IV.—LOCOMOTIVE BOILER.

An improvement in boilers, covered by Patent No. 423,406, issued to Martin Atock, of Dublin, Ireland, is shown in figs. 15 and 16. It consists in the introduction of a corrugated plate in the barrel of the boiler to provide elasticity and prevent undue strain from expansion and contraction. This may be done, as shown in fig. 15, by making the boiler with butt-joints and using corrugated joint-strips *f f f*. In this case each joint strip *f* has a corrugated cover *g*, of non-corrosive metal, to prevent pitting.

Another method, shown in fig. 16, is to form the tube-plate *a a* with a deep flange *b*, in which are two corrugations *c c*. The tube-plate and its flange lie completely within the barrel *d*, to which the flange is riveted at its edge ; *e e* represent the tubes, which are secured at the ends in any suitable manner. As the tubes expand relatively to the shell, either owing to their attaining a greater temperature or being formed of a metal having a higher co-efficient of expansion, the corrugations *c c* become flatter and allow the tube-plate *a* to take up a new position relatively to the shell.

Manufactures.

Heating and Lighting Passenger Trains.

The Chicago, Milwaukee & St. Paul Company has had in operation for some time, on one of its passenger trains, a special arrangement for supplying steam heating and electric light to the train. This is done by a " light and heat tender," which is a special car designed by Mr. George W. Gibbs, Mechanical Engineer of the road. This car, which is carried next to the tender and is mounted on passenger car trucks, has an unusually strong floor framing to protect it against accident, and is covered outside with steel plate ¼ in. thick, the end doors being also of steel. It is 34 ft. long by 9 ft. wide over all, and is divided into two parts by a partition, which is also covered with steel plate and provided with a steel door. The larger division is 20 ft. in length, and contains a boiler of the locomotive pattern, which supplies steam for heating the train and also for running the engine in the other compartment. Back of the boiler are placed the coal boxes, one on each side, leaving room between them for the fireman. The water supply is drawn from the locomotive tender. In the smaller division of the car is a Westinghouse engine of 15 H. P., which runs an Edison dynamo. This dynamo is connected with a switchboard from which wires are carried to the cars for the electric lights. The engine and dynamo are placed on one side of the car and their weight is balanced by a tank placed on the other side, in which is carried a supply of water for the boiler, which can be drawn upon when the engine is detached, or in case any accident should happen to the couplings connecting with the locomotive tender.

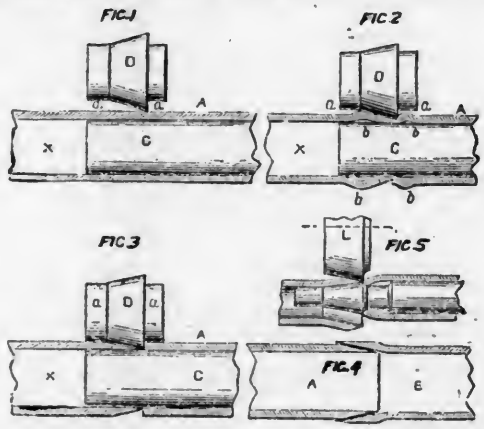
When the car was first placed in use a set of storage batteries was carried, in case the engine or dynamo should break down,

but this has been found unnecessary, and the batteries are no longer carried.

The system has been found to work very well. In the summer time, when it is not necessary to heat the train, the special car is laid aside and the dynamo and engine placed in the baggage car, steam being supplied to the engine from the locomotive boiler.

The Hartz Tube Welding Machine.

The machine illustrated by the accompanying engraving has been made for the purpose of cutting, preparing, piecing, and welding tubes, more especially such tubes as are used in locomotive and other boilers and require renewing at one or both ends, after wear. The machine is provided with a series of cutting and forming rollers, which are shown in figs. 1 to 5, which are diagrams intended to explain the action rather than



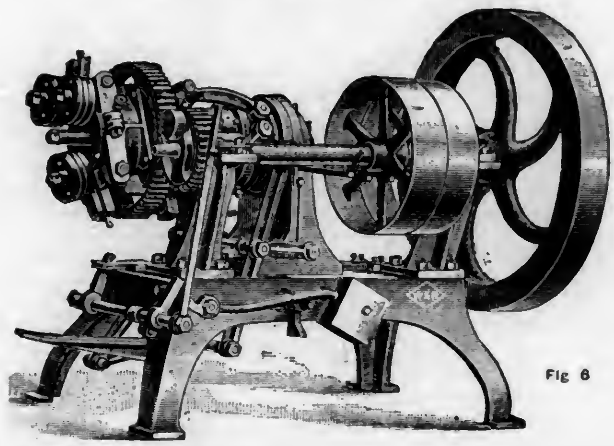


Fig 6

show the precise form of the rollers. Fig. 6 is a perspective view of the machine, showing the position of the rollers and the mandril upon which the tubes are cut, formed, and afterward rolled, when the joint is placed upon it at a welding heat. In fig. 1, *C* represents the mandril of the machine, and *D* one of the cutting and forming rollers, about to be forced into the tube as it rolls round it. Fig. 2 shows the same roller and tube after the roller has forced its way half through the thickness of the tube. Fig. 3 shows respective positions, and the form of the tube end when the bad piece has been severed from the main part, and the roller just touching the mandril. This part of the work being done, it is necessary to give the end of the piece of the new tube which is to be welded to it the form of the part marked *B* on fig. 4. For this purpose the roller *D* is changed for one with less taper, and, as shown in fig. 5, the mandril, which is movable, is changed end for end, the form of the end required for this purpose being as shown. By working it on this taper mandril, the end of the piece of tube is tapered outward, as shown in fig. 5, and the two pieces of tube now fit together, as shown in fig. 4. A number of tubes being thus prepared, the suitable cylindrical rollers are placed in the machine, the mandril changed so that its cylindrical part is under the path of the rollers, and the tubes at a welding heat are placed on the mandril and worked by the revolving action of the roller which runs round the tube, consolidates the weld and gives the tube the proper thickness.

The machine is made and introduced by Woodhouse & Rawson, of London, and is in use in several large railroad shops.—*The London Engineer.*

Marine Engineering.

The new syndicate which has purchased the land for an immense shipbuilding plant on the Delaware River below Mifflin Street is one of the most substantial concerns of the kind ever organized in this country, and the completion of the works at as early a date as possible is an assured fact. The capital stock is $5,000,000, of which the entire amount has been taken and is as good as paid in. Philadelphia leads in the enterprise not only in furnishing the site and the leading men, but of the $5,-000 000 subscribed $2,000,000 is placed in this city, while $1,000,000 has been taken in each of the cities of New York, Boston, and London.

The tract comprises 60 acres, extending from the Port Warden's line back to the old Point House Road, or, as it is now known, Weccacoe Avenue, and the consideration was $300,000 cash, or $5,000 an acre. A payment of $100,000 was made on Wednesday, and at least 500 men will be at work in a few days filling in and preparing the site.

The Cramps of the famous Kensington shipbuilding firm are the nucleus of the syndicate, and their idea is to transfer all their present works to the new site, while the Lehigh Valley Railroad Company will in all probability buy the land on which the Cramps are now situated, as it adjoins the property recently purchased by them on the river front.

Much of the success of the new enterprise has been due to the efforts of Wharton Barker, who, besides being largely interested personally in the syndicate, has had the practical charge of the finances of the venture, and his recent trip to Europe was to conclude the final arrangements on the other side. Matters were in excellent shape here, and as soon as Mr. Barker returned the business was brought to a climax as speedily as the legal forms could be complied with.

The new plant will be beyond all doubt the shipyard of the country, if not of the world. One of its features will be an immense dry dock capable of accommodating the largest vessels afloat or that may be designed for years to come. The site is admirably adapted for shipbuilding because of its location and the depth of the channel, there being 30 ft. of water at the Port Warden's line at that point.—*Philadelphia Record, June* 6.

The Continental Iron Works, Brooklyn, N. Y., have recently filled orders for corrugated furnaces for boilers as follows: 56 furnaces for cruisers 7 and 8, now building at the Brooklyn Navy Yard; 8 for the boilers of the new fire-boat *New Yorker;* 2 for the lighthouse tender *Azalea;* 16 to the Quintard Iron Works, New York, for the new cruiser, No. 11; 16 to the Morgan Iron Works, New York, for the steamer *Rhode Island;* 8 to the Union Iron works, San Francisco, for the steamer *City of Panama;* 2 to the Lake Erie Boiler Works, Buffalo, N. Y.; 3 to the Atlantic Iron Works, Boston; and 5 to M. T. Davidson, for the new boilers for the Brooklyn Water Works.

The new steamer *Seguranca* was launched from the yard of the Delaware River Shipbuilding Works at Chester, Pa., May 17. She is intended to run between New York and Rio de Janeiro, and is 336 ft. long over all, 45 ft. 6 in. beam, 27 ft. 9 in. deep to spar deck, and 4,890 tons displacement. The engine is of the triple-expansion type, with cylinders 30 in., 46 in. and 74 in. in diameter and 48 in. stroke. There are six steel boilers with corrugated furnaces, intended to work at 160 lbs. The *Seguranca* has very handsome passenger accommodations, and is provided with electric lights throughout.

The new steamer *City of Seattle* was recently launched from the yard of Neafie & Levy in Philadelphia. She is intended to run between Puget Sound and Pacific ports, and is owned by the Puget Sound & Alaska Steamship Company. She is 260 ft. long, 40 ft. beam and 17 ft. depth of hold, and has a compound engine, with cylinders 32 in. and 60 in. in diameter and 36 in. stroke. Steam is furnished by two steel boilers, each 13 ft. in diameter and 14 ft. long, built to carry 140 lbs. working pressure.

Manufacturing Notes.

Among the orders recently received by Riehle Brothers, Philadelphia, are the following: U. S. standard screw-power testing machines of 200,000 lbs. capacity for the Thomson-Houston Electric Company, Boston, and the Pittsburgh Forge & Iron Company; of 100,000 lbs. for Cornell University, the Western University of Pennsylvania, and the State University of Iowa; of 40,000 lbs. for the University of West Virginia. A horizontal testing machine of 200,000 lbs. capacity for the Gould Steam Forge Company, Buffalo, N. Y. Wire testers, 10,000 lbs. capacity, for the Thomson-Houston Electric Company; of 5,000 lbs. for Smith & Egge, Bridgeport, Conn. A

torsional testing machine of 5,000 lbs. capacity for the Thomson-Houston Company. Foundry testers of 5,000 lbs. capacity for the Keely Stove Works, the East Chicago Foundry, and the United States Rolling Stock Company. A testing machine for Coleman Sellers, Philadelphia. A cement tester, 1,000 lbs., to go to Charleston, W. Va., for the United States Government. Smaller orders include a large number for rope-twisters, marble-moulding machines, Robie screw-jacks, railroad scales, wagon scales, and smaller work.

THE American Bridge Works at Roanoke, Va., are building three iron draw-spans for the Norfolk Southern Railroad.

THE Haberkorn Brake Company has had a train of 25 freight cars fitted up at Fort Wayne, Ind., with the Haberkorn brake. This train will be used to illustrate the merits of the brake to railroad officers. The advantages claimed for it are an improved lever system, a very simple and elastic driver brake, full control given to the operator, and the use of a governor which limits the air pressure in the car cylinder and increases the pressure according to the load carried.

THE Fontaine Safety Signal Company, of Detroit, has had one of its signals in operation on the Michigan Central Railroad for nearly a year, and another on the New York Central & Hudson River near Spuyten Duyvil since last January. The signal in both cases meets with approval. Its object is to indicate to the engineer of a passing train the length of time which has elapsed since the preceding train passed. It is operated by the wheels of the train, and will indicate the time up to 20 minutes at each operation.

A SAFETY running-board, provided with railings and intended to prevent accidents to brakemen on the top of freight cars, has been invented by Francis W. Pool and Thomas N. Young of St. Paul, Minn., who are now introducing it.

THE Electric Merchandise Company, of Chicago, has bought the merchandise business of the Sprague Electric Equipment Company and will manufacture appliances of all kinds for electric railroads of all systems, including many improvements in car fittings, line material, etc.

THE South Boston Iron Company has decided to move its plant from Boston to Middlesboro, Ky. The removal will be made gradually, and the reason given for it is that the Company will secure a great reduction in cost of fuel, iron ore, etc. The South Boston Works have been engaged for a number of years in building heavy machinery, and during the war and since have also done a large business in casting of heavy guns for the Government.

Cars.

THE Scarritt Furniture Company, St. Louis, is furnishing its improved No. 34 seats for 24 new passenger cars for the Texas & Pacific Railroad; also the seats for 12 very handsome new passenger cars which the Harlan & Hollingsworth Company and the Ohio Falls Car Company are now building for the Louisville & Nashville Railroad. The Company has also received orders for Scarritt reclining chairs to fit up some very handsome chair cars which the Atchison, Topeka & Santa Fé Company is building in its shops in Topeka, Kan.

THE shops of the United States Rolling Stock Company in Anniston, Ala., have orders for 300 box cars for the Savannah, Americus & Montgomery; 300 coal cars for the East Tennessee, Virginia & Georgia, and 200 flat cars for the Montgomery, Tuskaloosa & Memphis Railroad. The shops of the company at Hegewisch, Ill., are building 90 caboose cars and 500 fruit cars for the Union Pacific Railroad. Of the fruit cars 100 are to be fitted to run on passenger trains.

THE Pullman Works, Pullman, Ill., are delivering a large number of coal cars to the Philadelphia & Reading Railroad. The order was for 4,000 cars.

THE Pardee Car & Machine Works, Watsontown, Pa., have recently completed orders for 250 box cars of 25 tons capacity for the Central Railroad of New Jersey, and a number of 30-ton coal cars for the Beech Creek Railroad.

OBITUARY.

FRANCIS C. LOWTHORP, who died in Trenton, N. J., June 1, aged 81 years, was well known as an engineer of many years' standing and one of the earliest builders of iron bridges in this country. At his works in Trenton he made many turn-tables and a number of bridges—most of the latter on a plan devised by himself, with cast-iron posts and top chord and a bottom chord of iron plates. The bridges on the Newark Branch of the Central Railroad of New Jersey were of this type. Mr. Lowthorp was a Fellow of the American Society of Civil Engineers.

FRANK A. LEERS, who died in Paterson, N. J., May 19, aged 46 years, was a native of Prussia, and received his early training as an engineer in that country. He came to this country in 1871, and was for several years in St. Louis, being employed on the St. Louis Bridge, at the Carondelet Furnace, and on city work under Colonel Flad. In 1878 he came to New York as Assistant Engineer on the Manhattan Elevated, and in 1880 was appointed Engineer of the Bridge Department of the Passaic Rolling Mill Company, a position which he held until his death.

CHARLES ACKENHEIL was killed in an accident on the Baltimore & Ohio Railroad near Childs, Del., June 19, the car in which he was riding being derailed. Mr. Ackenheil was an engineer of standing and experience, and had been for some time Chief Engineer of the Staten Island Rapid Transit Company. He was born in Baden-Baden in 1842, and was a graduate of Heidelberg University. He came to this country when he was about 19 years of age. He was a member of the American Society of Civil Engineers, built the bridge over the Monongahela for the Wheeling & Pittsburgh Railroad, and was one of the designers of the Arthur Kill Bridge. He had been connected with the Baltimore & Ohio Company for 20 years, and when, in 1885, that Company became interested in the Staten Island Rapid Transit Company he was appointed its Chief Engineer. When the accident occurred he was traveling on official business for the Company.

PERSONALS.

JOHN PLAYER has been appointed Superintendent of Motive Power of the Atchison, Topeka & Santa Fé Railroad. He was lately on the Wisconsin Central.

WILLIAM MILLER, late of the St. Louis, Vandalia & Terre Haute, has been appointed Superintendent of Motive Power of the Columbus, Hocking Valley & Toledo Railroad.

E. F. C. DAVIS, late Mechanical Engineer of the Philadelphia & Reading Coal & Iron Company, is now General Manager of the Richmond Locomotive & Machine Works at Richmond, Va.

HARVEY MIDDLETON has been appointed Superintendent of Motive Power of the Union Pacific Railroad. He was formerly on the Louisville & Nashville and more recently on the Atchison, Topeka & Santa Fé.

FRANK L. SHEPPARD has been appointed General Superintendent of the Pennsylvania Railroad Division of the Pennsylvania Railroad, succeeding Robert E. Pettit, resigned. Mr. Sheppard has been on the road for 22 years, serving in various grades; for eight years past he has been Superintendent of Motive Power of the Pennsylvania Railroad Division. His successor in the last-named office is J. M. WALLIS, who has served 13 years on the road, holding various positions in the Motive Power and Operating departments.

GEORGE W. CUSHING has resigned the position of Superintendent of Motive Power of the Union Pacific Railroad, to which he was appointed in February, 1889. He is for the present residing in Chicago. Mr. Cushing has had experience on many important roads, having had charge of the machinery department on the Kansas Pacific, the Wabash, the Missouri, Kansas & Texas, the Northern Pacific, and the Philadelphia & Reading, before going to the Union Pacific. He also served on the Chicago & Northwestern for a number of years.

PROCEEDINGS OF SOCIETIES.

National Conference of Railroad Commissioners.—The second yearly conference of Railroad Commissioners met in Washington, May 28, nearly all the State commissions being represented. Judge Thomas M. Cooley, of the Interstate Commission, was chosen Chairman; Commissioner E. P. Jervey, of South Carolina, Vice-Chairman, and Mr. Edward A. Moseley Secretary. Judge Cooley made a short address.

The Committee appointed last year made a report on Means for Securing Harmony in Railroad Legislation. The report set forth the necessity for harmony, and presented resolutions which were finally passed, with some amendments, as follows:

"*Resolved*, That it is expedient that the laws of the several States should be in harmony with the laws of the United States on the following topics:

"The definition and prohibition of unjust discrimination.

"The prohibition of undue and unreasonable preferences and advantages.

"The requirement of equal facilities for the interchange of traffic.

"The regulation of the relations between rates of compensation to be allowed for long and short hauls.

"The regulations as to printing and posting rates, fares and charges.

"The regulations as to notice to be given of advances and reductions in rates.

"The penalties for false billing, false classification, false weighing, etc.

"*Resolved*, That the respective States should require either directly by law, or indirectly through the instrumentality of their railroad commissions, each railroad corporation subject to their jurisdictions to place driving-wheel brakes and apparatus for train brakes upon every locomotive hereafter constructed or purchased by it, and train-brakes upon every train, and also place upon every freight car hereafter constructed or purchased by it and upon every freight car owned by it, or the coupler or drawbar of which is repaired by it, an automatic coupler of the M. C. B. type at each end of the car.

"*Resolved*, That Congress either directly by law or indirectly through the instrumentality of the Interstate Commerce Commission should take similar action."

On the second day the various questions prepared by the Committee were taken up for discussion. On Regulating Railroad Construction a committee was appointed to consider the question of securing some uniform legislation. On State Railroads a committee was also appointed to consider how they could be brought under the interstate law.

Reasonable Rates were discussed at length, and a committee appointed to report next year.

On Annual Reports the Committee appointed last year presented a report, which was discussed at length and finally referred back, with instructions to prepare a report on the whole subject of reports and accounts.

On Classification of Freight there was a long discussion, in which the importance and great convenience of a uniform classification for the whole country were strongly used.

It was resolved that the next conference be held in Washington, on the first Wednesday in May, 1891, and the Convention then adjourned.

Master Car-Builders' Association.—The 24th Annual Convention began at Old Point Comfort, Va., June 10. President McWood delivered his annual address congratulating the Association on the progress made during the past year. The Secretary's report showed that there are now 141 active, 100 representatives and 6 associate members, making a total of 247. The number of cars represented is 911,417, an increase of over 100,000 during the year.

On the first day reports were presented by the Committees on Standard Marking of Freight Cars; on Best Material for Brake Shoes; on Steam Heating and Ventilation; on Passenger Cars; and on the Rules of Interchange. The report on Brake Shoes contained an account of the tests made under charge of the Committee, but was not a final one. The report on Steam Heating gives evidence of much progress in that direction, but was also not a final one. The two committees were continued until next year. All these reports were discussed by the Convention.

The second day was devoted to the discussion of the Rules of Interchange, in which a number of slight changes were suggested by the Committee and by others.

A large number of supply firms were represented at the Convention by exhibits of their productions.

On the third day reports were presented by the Committees on Journal box, Bearing and Lid for 60,000-lbs. Cars; on Steel Plate and Malleable Iron in Car Construction; on Loading Bark and Logs on Cars; and on Height of Draw-bars for Passenger Cars. All of these reports were discussed.

The recommendations of the Committees on Height of Drawbars and on Standard Fittings and Couplings for Steam Heating were ordered referred to letter-ballot.

For the place of meeting for next year a majority of votes favored Cape May.

The officers elected for the ensuing year are: President, John Kirby, Cleveland, O. Vice-Presidents, E. W. Grieves, Baltimore; John S. Lentz, Packerton, Pa.; T. A. Bissell, Buffalo, N. Y. Treasurer, G. W. Demarest, Baltimore. Members of Executive Committee, J. N. Barr, Milwaukee, Wis.; W. H. Day, Florence, S. C.; J. W. Marden, Boston. John W. Cloud was re-elected Secretary.

Master Mechanics' Association.—The 23d Annual Convention began at Old Point Comfort, Va., June 17, with a large attendance. An address of welcome was delivered by Mr. M. E. Ingalls, after which Mr. R. H. Briggs delivered his annual address as President. The Treasurer reported a balance of $1,081 on hand. The Secretary reported a total of 363 members, of whom 334 are active, 15 associate, and 14 honorary members.

A resolution was passed authorizing the appointment of a committee to arrange for the investment of the Boston fund in scholarships at the Massachusetts School of Technology, the Stevens Institute, and Cornell University.

The questions for discussion offered on the first day were the Method of Fitting Bolts; and Is It Safe to Run a Pony Truck under Fast Express Trains? The Committee on Compound Locomotives presented its report.

On the second day this report was discussed. The Committee on the Establishment of Testing Stations presented no report, and was continued until next year. Reports were also presented by the Committees on Position of Fire-box, and on Steel and Iron Axles.

On the third day the remaining committee reports were presented and discussed. An abstract of these reports will be found elsewhere in this number.

The remainder of the third day's sessions was devoted to the transaction of the usual routine business. It was decided to appoint a committee to confer with a similar committee from the Master Car Builders' Association to make arrangements, by which the meetings of both associations can be held at the same place, and the time so arranged as to require less than the two weeks' attendance which must now be given by those who are members of both associations.

The following officers were elected for the ensuing year: President, John Mackenzie, Cleveland, O.; First Vice-President, John Hickey, Kaukauna, Wis.; Second Vice-President, William Garstang, Richmond, Va.; Treasurer, O. Stewart, Boston, Mass.; Secretary, Angus Sinclair, New York.

American Society of Railroad Superintendents.—The officers now are: President, C. S. Gadsden, Charleston, S. C.; Secretary, C. A. Hammond, 350 Atlantic Avenue, Boston, Mass. The annual meeting will be held in New York on the day preceding the fall meeting of the General Time Convention.

American Water Works Association.—The annual convention began in Chicago, May 21, and continued for three days. The sessions were well filled up with the reading of papers and with discussions.

Among the papers read and discussed were included the following subjects: Hydrants, by Edwin Darling; Book-keeping for Water Departments, by J. P. Donahue; Water Power of Rock River, Michigan, by S. McElroy; Basis for Schedules of Water Rates, by J. N. Tubbs; Water Supplies, by C. Monjeau; Public Filtration, by J. J. Caldwell; Water Rates, by C. N. Priddy; Water Meters, by J. H. Decker; Pumping Machinery, by Charles A. Hague; Artesian Wells, by J. T. Lakin; Water Works Construction, by F. L. Fuller.

The following committees were appointed, to report to the next convention: On Water Supplies, A. R. Leeds, J. L. Le Conte and L. H. Gardner. On Specifications for Cast-iron Pipe, T. W. Yardley, S. B. Russell and A. J. Guilford.

The annual banquet of the Association was given on the evening of May 22. On the morning of May 23 the members visited the water works at Elgin and afterward the city of Pullman.

The officers chosen for the ensuing year are: President, William B. Bull, Quincy, Ill. Vice-Presidents, G. H. Benzenburg, Milwaukee, Wis.; J. A. Barnes, Chicago; I. L. Lyman, Lincoln, Neb.; R. M. Ellis, Boston; H. F. Dunham, Cleveland, O. Secretary and Treasurer, J. M. Diven, Elmira, N. Y.

The next convention will be held in Philadelphia in April, 1891.

American Society of Mechanical Engineers.—The Society has occupied its new house at No. 12 West Thirty-first Street, New York City, which is thus described in a circular issued by Secretary F. R. Hutton:

"The Society will occupy the parlor at the right of the entrance as its business office and members' rendezvous, and the library will be on the second floor. This second floor has been fitted up by its former owners as a library area, and has a capacity for 20,000 volumes. As the present library of the Society numbers less than 2,000 volumes, it will be seen that there is room for abundant growth. The second story small front

room will be the Secretary's private office. The third story rear room will be used as a room for photographs, drawings, and collections of models and apparatus, and in this room, with a sunny southern exposure, will be kept a drawing table and usual instruments for the use of non-resident members who may find such an outfit a convenience when in the city. The incandescent electric light is to be put into the building throughout, which will add very much to the comfort of every one, particularly of readers at night and in warm weather.

"Back of the entry and parlor-office on the ground floor is the large auditorium, two stories in height, with seating capacity for over 200, electrically lighted and ventilated by mechanical means. This auditorium to be redecorated, and new and more comfortable seats are to be put into it. The telephone service will be provided as heretofore, for the convenience of the members.

"The house is 28 ft. 4 in. wide, and is 175 ft. west of Fifth Avenue. The house and lot cost $60,000. Of this sum, $33,000 are left on bond and mortgage by its former owners, and the balance was subscribed for and loaned by interested members of this Society. Considerably more has been subscribed than is actually needed, although not enough to clear off the mortgage entire."

American Institute of Electrical Engineers.—The annual meeting was held in New York, May 20, when the reports showed that there were now 427 members, and that the Institute was in a very prosperous condition.

The officers elected for the ensuing year were as follows: President, W. A. Anthony, Manchester, Conn. Vice Presidents, Francis B. Crocker, Frank J. Sprague and Joseph Wetzler, New York. Managers, P. B. Delany, South Orange, N. J.; Horatio A. Foster and J. C. Chamberlain, New York. Treasurer, George M. Phelps. Secretary, Ralph W. Pope, New York. The officers of the Institute are now at No. 12 West Thirty-first Street, New York.

On the following day a meeting was held in Boston, at which a number of papers were read. The meeting closed with a dinner in the evening.

American Society of Civil Engineers.—At the regular meeting, May 21, there was a general discussion on Cement, in which notes of experience were presented by Messrs. Gould, Bates, Collingwood, Worthen, Buck, Brush, Crowell, Odell and others, many interesting points being brought forward.

AT the regular meeting in New York, June 4, the death of F. C. Lowthorp, Fellow of the Society, was announced.

Mr. J. Foster Crowell read some notes of a Visit to the Line of the Panama Canal.

The Tellers announced the following elections: Members: Rawlinson T. Bayliss, Marysville, Mont.; Harry W. Edwards, West Superior, Wis.; John E. Greiner, Baltimore, Md.; Carl R. Grimm, Trenton, N. J.; John B. Henderson, Brisbane, Queensland, Australia; Karl E. Hilgard, Cincinnati, O.; Gilbert Hodges, Boston, Mass.; Charles C. Hopkins, Gloversville, N. Y.; Andrew L. Johnston, Richmond, Va.; Claude W. Kinder, Tientsin, China; William McK. Marple, Scranton, Pa.; Charles E. Marvin, Macon, Ga.; Mitsugu Sengoku, Tokyo, Japan; Reuben Skirreffs, Paterson, N. J.; Charles W. Walton, Detroit, Mich.; Ethelbert G. Woodford, Pretoria, Transvaal Republic.

Juniors: Wainwright Parrish, Albany, N. Y.; George E. Roehm, Detroit, Mich.; William L. Sisson, Baltimore, Md.; Charles H. Smith, Middletown, N. Y.

THE annual convention was to be held at Cresson, Pa., beginning June 26. The programme included one business session, several sessions for reading and discussion of papers, the annual address by President Shinn and the yearly dinner. A number of important papers were presented at the convention.

New England Water-Works Association.—The Annual Convention began in Portland, Me., June 11. President Brackett delivered an address showing the progress of the Association and the work accomplished. The Secretary reported that there are now 335 members.

The Committee on Classification of Water Rates presented a report showing that there was a very wide difference, and coming to no final conclusion. The Committee was continued for another year.

A number of new members were elected.

A paper on Public and Private Ownership of Water Works, by C. W. Morse, was read and discussed.

On the second day papers on Analysis of Water, on Cement Pipe and on Water-Works in Holland were read, and Mr. A. Fteley gave a description of the new Croton Aqueduct in New York illustrated by lantern views. There were also discussions on a number of questions suggested by members.

At an evening session papers on Recording Gauges; on Water Meters and on Ground Water-Supply were read and discussed, and the topical discussions continued.

The third day was devoted to a visit to the Portland Water Works at Lake Sebago, 17 miles from the city, which were carefully examined by members. The annual banquet of the Association was held on the evening of the first day of the Convention.

Boston Society of Civil Engineers.—At the regular meeting, May 21, Professor Thomas M. Drown, Professor William T. Sedgwick and Mr. George F. Chace were elected members.

The Committee on Affiliation with the American Society of Civil Engineers made a report, recommending a plan providing for interchange of papers, joint publication and general mutual exchange of privileges of members, without surrender of separate organizations.

Mr. S. L. Minot read a paper on Improved Railroad Terminal Facilities for Providence, giving the history of the various plans offered for improving the station accommodations in that city, and describing the plan finally adopted, which was prepared by Mr. Minot and Mr. E. P. Dawley, Chief Engineer of the New York, Providence & Boston Railroad.

Mr. L. B. Bidwell read a paper describing the Asylum Street Improvement in Hartford, Conn., and the new station in that city.

Engineers' Club of Philadelphia.—At the regular meeting, May 17, Professor J. W. Redway read a paper on the Physical Geography of the Mississippi River.

The Secretary presented, for Mr. George W. Creighton, a paper on Rail Joints.

The meeting concluded with a lunch, arrangements having been made to provide one at each regular meeting.

AT the regular meeting, June 7, resolutions were passed offering the use of the Club rooms on an occasion of the reception of the British Iron & Steel Association.

The Secretary presented for Mr. Strickland L. Kneass a description of the new condensed and refrigerating system.

Engineers' Society of Western Pennsylvania.—At the regular meeting in Pittsburgh, May 20, the Committee on Relations with American Society of Civil Engineers—W. L. Scaife, Thomas P. Roberts and John W. Langley—reported in favor of a federation of the other engineering associations with the American Society for certain purposes of general concern, each association to preserve its individuality. The report was approved, and the scheme as suggested will be submitted to the American Society.

Mr. M. J. Becker read a paper describing the work of building the bridge over the Ohio River at Steubenville, O., for the Pittsburgh, Cincinnati & St. Louis Railroad.

Engineers' Club of Cincinnati.—At the regular May meeting of the Club Messrs. W. H. D. Totten, Jr., Alfred Koechlin, G. P. Walker, and John C. Lemon were elected members.

An agreeable diversion from the regular programme of reading a paper on some engineering subject was observed, and in its stead the members and their lady friends and some invited guests listened to a very interesting lecture by Colonel William E. Merrill, U. S. Engineers, on a Hasty Trip to the Paris Exposition.

The lecture was illustrated with some 90 lantern pictures prepared from photographs secured by Colonel Merrill while on a visit to Europe in the fall of 1889 with the American engineers who made the tour of Europe.

The lecture comprised a description of the Forth Bridge and the Eiffel Tower, and a short historic sketch of many places of interest and renown in European countries.

Civil Engineers' Club of Cleveland.—At the regular meeting, June 10, Mr. Albert H. Porter was elected Secretary. Messrs. Edward P. Roberts, William H. Dunn, James Hallstead, John H. Hilton and William F. Biggar were elected members; Joseph Daniels, Thomas M. Irvine and William Otis, associate members

A committee of five was appointed to make arrangements for the annual picnic to be held at Rocky River in the latter part

of July. The receipt of several books, pamphlets and photographs was announced.

Dr. Herman Poole read a paper on Ferroid, which is a new artificial stone, and the paper was discussed.

Professor Charles S. Howe read a paper on the Almucanter, a new instrument for field astronomy, which greatly simplifies observations and calculations for time and latitude. This was illustrated by a large drawing prepared by Professor Saunders, and called out a long discussion.

Engineering Association of the Southwest.—At the regular meeting in Nashville, Tenn., June 12, several communications were read and referred to proper committees. Mr. W. C. Smith presented the Association with a group of framed views of the Forth Bridge and the Eiffel Tower.

The Committee on the Cause of Setting of Cement requested more time, in consequence of the illness of members of the Committee. The Committee on Affiliation with the American Society reported that it had been impossible for any member to attend the meeting in New York, June 4, and asked to be discharged. There was a short discussion on this subject.

Mr. John B. Atkinson read a paper on Coke Making in the Western Kentucky Coal Field, which described a series of experiments carried on at Earlington, Ky., for the purpose of desulphurizing coke. These experiments are not yet completed, but are of great importance, for should they be successful there will be a largely increased demand for Kentucky coal, which is at present unsuited to iron making.

Western Society of Engineers.—At the regular meeting in Chicago, May 7, a communication relating to affiliation with the American Society of Civil Engineers was referred to a special committee.

The subject for discussion was the reports presented on the Railroad Problem in Chicago. These reports were thoroughly discussed by members present. Figures were presented for the cost of elevated railroads, and a new plan was described for a four-track steel viaduct on brick piers.

Engineers' Club of St. Louis.—At the regular meeting, May 21, it was announced that the purse to be presented to the son of the late Professor Smith, for many years Secretary of the Club, had reached the amount of $270.

A paper by George A. Brown on the Function of the Government in a Plan for General Irrigation was read. The paper discussed the necessity for a general system of law to govern irrigation and water rights and argued in favor of a Government title to water privileges. Incidentally it discussed rainfall in general and as affected by forests.

The paper was discussed by Messrs. Blaisdell, Curtis, Johnson, Moore, Nipher and others. Professor Nipher said that experiments extending over a long period of years had demonstrated that the apparent increase in rainfall in forests was due to the fact that the rain caught in the gauges was not affected by wind currents. Improved forms of rain-gauges had shown that there was no actual difference between the amount of rain falling in forests and in open places.

AT the regular meeting, June 4, J. G. Jennings was elected a member.

Colonel Meier, President of the Committee on Eads Monument, announced the formation of the Eads Monument Association, and suggested the advisability of members of the Club joining that association.

Mr. Russell, Chairman of the Committee on Local Data, then presented his report. The nature of the matter collected was explained, and the ground covered and the names of the contributors were given. Some informal discussion of the matter presented took place. It was ordered that the committee be continued, with authority to employ expert assistance, if necessary, to edit the report, and to secure for the Club estimates on the cost of publication.

Professor Nipher called attention to the fact that rainfall in the State of Missouri was almost exactly equivalent to the river discharge at St. Louis.

Engineers' Club of Kansas City.—At the regular meeting, May 12, Mr. A. Clifford Thomson was elected a member.

The Committee on Affiliation of Engineering Societies present a brief report adverse to a connection with the American Society of Civil Engineers; also several communications. After a short discussion the report was accepted and the Committee continued.

The Secretary read a paper by Mr. Robert M. Sheridan on the Evolution of the Elevator, tracing the growth of the elevator engin up to its present stage of development.

Denver Society of Civil Engineers.—At the regular meeting, May 28, Mr. W. W. Follett read a paper on Dams and Reservoirs, treating both of methods of construction of dams and of the best locations for reservoirs. The paper was written with special reference to the storage of water for irrigation purposes.

The reading was followed by a general discussion of the subject by members present.

Technical Society of the Pacific Coast.—At the regular meeting in San Francisco, May 2, Mr. P. M. Randall read a paper on the Pohle Pumping System, giving a mathematical analysis from formulæ of his own construction.

NOTES AND NEWS.

Russian Torpedo-Boats.—The Imperial Russian Government has just received three new torpedo-boats from Mr. Schichau, of Elbing. One of these is described as follows in *Engineering*:

"The torpedo dispatch boat *Adler* belongs to a new type introduced by Mr. Schichau, and is similar in principle to the boats built for the Italian Navy, *Aquila, Nibbio, Falko, Avoltoio, Sparviero.* She is a twin-screw boat of 46.5 meters (152 ft. 7 in.) length and 5.2 meters (17 ft.) breadth, and displacement about 150 tons. She is fitted with two locomotive boilers and twin engines of about 2,300 indicated horse-power collective. The speed guaranteed was 26.5 knots per hour during a two hours' continuous run, and in many well-informed circles the accomplishment of this feat was looked at as impossible. The mean speed of the *Adler* during two hours was 26.55 knots per hour. The Russian Government possesses in this steamer one of the fastest vessels in the world. All three ships will shortly be taken out by Russian officers and crews round Europe to the Black Sea."

Growth of Trades Unions in England.—A correspondent of the *Engineer* says: "In connection with the various Trades Unions' Organizations, the enormous growth of membership which has been going on during the past year is a matter which deserves serious consideration, as although the societies naturally congratulate themselves upon this apparent addition of strength to their ranks, it is not improbable that in the event of any serious slackening off in trade this largely increased membership may become a source of weakness. With the object of swelling their numbers, some of the societies have not been very particular as to the class of men they have admitted, and the result may be, that directly there is a decreasing activity in the workshops, large numbers of these men may be thrown upon the books of the societies for out-of-work support. The Amalgamated Society of Engineers has been making more progress than any other society in increasing its membership, and during the past month there has been a further addition of something like 700 members. The same thing is going on in smaller societies, the United Machine Workers' Association, whose annual report has just been issued to the members, having during the past couple of years more than doubled the number of its members, and during four years the society has increased from a membership of 370, with nine branches, up to a membership of over 2000, with twenty-eight branches. With regard to the funds of the associations, it may be interesting to notice that the Steam Engine Makers' Society is now for the first time able to report a larger accumulation of funds in proportion to membership than the Amalgamated Society of Engineers, the declared value of the Steam Engine Makers' Society being now £3 10s. 4½d., and of the Amalgamated Society of Engineers £3 9s. 1d. per member. The Amalgamated Engineers' Society at one time was able to declare a value of £6 3s. 5d., and the Steam Engine Makers of £4 1s. 4d. per member, so that both of the societies have still a great deal to do in the accumulation of funds to place them in the same satisfactory position that the organizations occupied only a few years ago."

The Eiffel Tower as a Lightning Rod.—In an English paper it is said that a thunderstorm of exceptional violence has passed over Paris, and the Eiffel Tower has borne the brunt of a severe thunderbolt experience. The gigantic structure has stood the test magnificently, and when scientific men have put their heads together and summed up the results of the storm, we can hardly doubt that the conclusion must be in favor of the tower as a huge lightning-rod which relieves the rest of Paris of dangers and presents no probable danger from elemental strife

in itself. During the exhibition there were various storms through which the tower passed scathless, like an iron ship at sea. But during the heavy discharge of atmospheric artillery on Saturday, May 10, 1890, the tower was struck six times, and thus the test of its electric conductivity was excellent. Not the slightest damage resulted either to the structure or to any person occupied on its various stages. The lightning was distinctly seen to zigzag toward the summit and to track its way down the column. Vibration of some kind was experienced, but whether from the discharge of electricity, or from the loud peals overhead, is perhaps a moot point. We are inclined to think that a recent discussion on the utility of lightning-rods may be drawn to a conclusion by this experience of the Eiffel Tower, and that the promoters of the great tower in London, which is to be not less than 1,200 ft. in height, may proceed courageously with their work, possessed with the assurance that if the structure accepted be not beautiful, it may at least be useful.

Colors of British Locomotives.—The locomotives on the Glasgow & Southwestern Railway are painted black; those on the London & Southwestern, light green, approaching a pea green; on the Caledonian and the Great Eastern, dark blue; on the North British and the London, Brighton & South Coast, yellow ochre.

Magazine Rifles for the Indian Army.—It is anticipated that the whole of the British infantry garrison in India will be armed with the new rifle before the close of the year. Eight thousand magazine rifles should have reached India by now, and another six thousand are being dispatched this month.

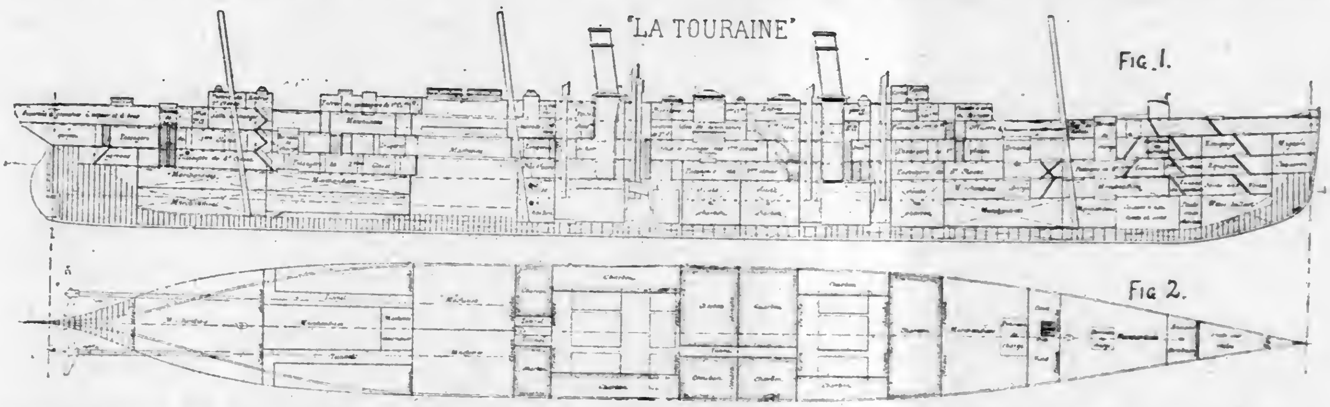
Export of Scotch Locomotives.—During the first three months of this year there were exported from Scotland locomotives of a total value of £90,469, against a quarterly average of £90,000 last year, and of £71,000 in 1888. The value of those shipped during the first quarter of this year to the Continent was £50,000, and those to Australasia £14,000.

Flameless Combustion.—In a recent lecture on "Flameless Combustion," Mr. T. Fletcher said: "The appearance of flame is misleading, and the greater the flame the smaller the work done, other things being equal. I have been asked by a well-known engineer if I could explain why certain boilers gave such an exceedingly small duty for the fuel consumed when the flues were, as he said, 'filled from end to end with magnificent flame.' The fact was that his so-called magnificent flame was a delusion, hollow and cold inside, and not coming in contact with his boiler at all. When the same fuel was burned with a very small flame, hardly visible over the bridge, the duty increased some 30 per cent."

A Point of Honor not Sustained.—The *Engineer's* commercial correspondent from the North of England writes to that paper: "It will be remembered that when the engineering employers on the Tyne and Wear conceded a short time since to their workmen the right of leaving work at twelve instead of one o'clock on Saturdays, it was agreed on behalf of the men that there should in the future be less time lost in and after general holidays. The latter were more clearly specified than before. Among others they were to include Whit Monday, but not Whit Tuesday. One paragraph in the agreement ran as follows: 'That any man or men not returning to work at the proper time after the holidays may be suspended or dismissed without notice, it being understood that the men suspended or dismissed shall not receive any benefit from their Society until they have worked a month, according to their Society's rules. The men's delegates promise, on their part, to represent to the men that it is a point of honor to act up to the spirit of this agreement.' Inasmuch as last Monday was the first occasion on which the new arrangement came into force, it was a matter of great and general interest to see whether the men, having obtained what they wanted in the way of the extra hour on Saturday, would honorably fulfil their part of the agreement and come to work on Tuesday morning, notwithstanding old habits and many temptations to prolong their holiday. As far as can be at present ascertained, the only works where the men acted fairly up to the spirit of the agreement were those at Elswick. At almost all others the attendance was either so poor that it was not worth while to keep the machinery going, or the men, after putting in an appearance, went away and did not return for the rest of the day. It appears almost impossible to get average workmen to keep agreements or honorable understandings, whatever their representatives may undertake in their behalf, and employers have just to put up with the loss and damage sustained thereby as best they can. It would seem that the Elswick men are decidedly superior to the average in this respect."

A failure to keep such agreements is the most serious obstacle in the way of carrying out amicable agreements with workingmen or their representatives. Those who fail to act up to the spirit of such honorable understandings are the greatest enemies to the true interests of the men, as they make amicable agreements between their employers and themselves useless and such relations as should exist between honorable men impossible.

A New French Steamer.—The latest steamer of the Compagnie Generale Transatlantique—*La Touraine*—was recently launched at Havre. This ship is 516½ ft. long between perpendiculars, 56 ft. beam, and draws 23.6 ft. of water. She will have accommodations for 392 first-class, 114 second-class, and 540 steerage passengers—1,046 in all—and all the cabin arrangements are of the latest and most approved types.



The ship will have two three-bladed screws, 19.7 ft. in diameter. Each screw is driven by a separate triple-expansion engine, of the vertical type, with cylinders 41 in., 60½ in. and 100 in. in diameter by 65½ in. stroke. The crank shafts and screw shafts are of steel, forged at the Creusot Works, and are hollow, the external diameter being 20.3 in. and the internal 6.3 in.

There are 12 boilers, 14 ft. 9 in. in diameter and 20 ft. 4 in. long. Nine of them are double, each with six corrugated cylindrical fire-boxes, three at each end, and the other three are single, with three fire-boxes each. They are provided with forced draft on the Audenet system.

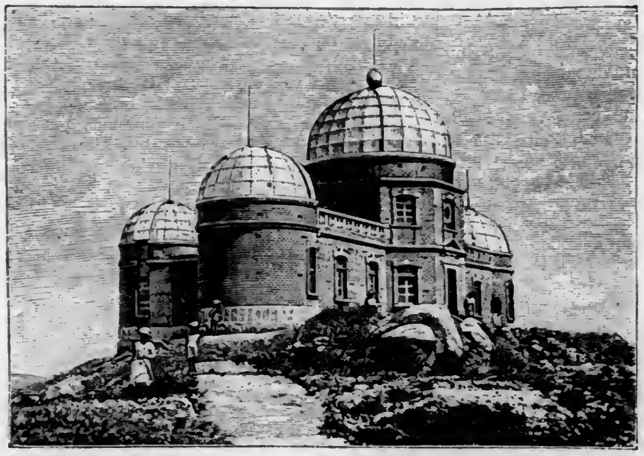
La Touraine is expected to reach a speed of 19½ knots an hour on trial, or about 18¼ knots in actual service. She is intended for the line between Havre and New York. The ship and engines were designed by M. Daymard, Chief Engineer of the Company, and built at St. Nazaire. In the accompanying illustrations—from *Le Genie Civil*—fig. 1 is a sketch showing a longitudinal section of the ship; fig. 2 a sketch plan of the lower deck, showing the positions of the engines, boilers, and screws.

Metal Taper Tubes for Telegraph Poles.—The trades correspondent of the *Engineer*, writing of the Birmingham, Wolverhampton and other districts, says that there is a heavy outturn at date of metal taper tubes for telegraph poles and also of wrought-iron flange pipes for South Africa for the conveyance of water.

The Fastest Cruiser.—At the yards of Armstrong & Company in Elswick, England, there was recently launched the armored cruiser *Necochea*, for the Argentine Republic, which is expected to be the fastest warship afloat. This vessel is 300 ft. long, 43 ft. beam and 3,200 tons displacement; she will carry two 21-cm. (8.27-in.) breech-loading rifles, eight 12-cm. (4.72-in.) rapid-fire guns and 24 smaller rapid-fire and machine guns, besides torpedo tubes.

The engines of the *Necochea* are expected to develop 13,500 H.P., and to propel the ship at a speed of 22 knots—nearly 26 miles—an hour, and it is hoped that this may be slightly exceeded on trial.

An African Observatory.—A remarkable scientific establishment has just been completed by M. Colin, which is the only observatory on the east coast of Africa. It is on the island



of Madagascar, and is placed at an altitude of 1,400 meters (about 4,600 ft.), on the summit of a mountain a few miles from Tananarivo. It is a handsome structure of cut stone, with four cupolas. The cost was met by contributions from persons and associations interested in developing French influence in that country. It has also the support of the French Academy of Sciences.

Besides astronomical work, M. Colin has organized a regular service for meteorological observations with posts at different points on the island.

The observatory is well supplied with instruments, including a magnetograph, and valuable results are expected, both astronomically and in information concerning the climate and meteorological conditions of Madagascar and the neighboring seas, heretofore but little known.

The accompanying illustration is from a photograph, attached to a paper prepared by M. Mascart for the Academy of Sciences.—*Le Génie Civil.*

Forced Draft.—The British Admiralty appear to be coming round to the view that most naval officers took some time ago, that forced draft is a mistake, and they are disposed to substitute for it an improved natural draft. Manufacturers of engines say that four hours' steaming under forced draft takes about four years' wear out of a ship's boilers. Engineers in the British Navy are not allowed to use the forced draft except in vessels fitted with locomotive boilers.

Coal Mining in Japan.—The correspondence of the *Economiste Française* says that the total production of coal in Japan in 1889 was 6,105,126 tons, an increase of 39.2 per cent. over the previous year. The most important producing point is the Miike Mine in Foukonoka, from which 1,106,772 tons were taken last year; the next is the Karatsou Mine in Saga, from which 262,237 tons were taken.

Coal is produced in 13 departments, and is of varying quality. The production last year is valued at $14,461,070, an average of $2.37 per ton.

The Bay City Water Works.—The report of Mr. E. L. Dunbar, Superintendent of the Water Works of Bay City, Mich., shows that the plant of these works includes one Gaskill horizontal, compound, condensing, crank and fly-wheel pumping-engine, having a maximum capacity of 5,000,000 galls. in 24 hours, or 121 galls. per revolution; one Holly quadruplex, compound, condensing, crank and fly-wheel pumping-engine, having a maximum capacity of 3,000,000 galls. in 24 hours, or 55 galls. per revolution; one horizontal, high-pressure, piston engine driving through gearing two No. 10 Holly rotary pumps, having a maximum capacity of 2,500,000 galls. in 24 hours, or 17 galls. per revolution. The fuel used is pine slabs and edgings, of which 2,338 cords were used during the year, the average cost, including the labor of delivering from the wood-yard to the fire-room, being 71.3 cents per cord. The net cost of running the pumping-engines for the year was $5,721, being an average of $6.06 per million gallons pumped, or $5.49 per million gallons raised 100 ft. The detailed statement of performance is as follows:

"The Gaskill engines have been run during the year 8,659 hours and 27 minutes, having been shut down 100 hours and 33 minutes for repairs, packing, etc. The longest continuous run of these engines was 36 days, from August 20 to September 25.

"The Holly quadruplex engines have been run 123 hours and 53 minutes, 24 hours and 5 minutes of which was with the Gaskill engines in operation, and 99 hours and 48 minutes pumping the entire city supply.

"The high-pressure engine and rotary pumps have been run 45 minutes, during which time they pumped the supply of the city.

"Total quantity of water pumped:

By Gaskill engines	929,305,047 galls.
By quadruplex engines	15,055,755 "
By rotary pumps	111,945 "
Total	944,472,747 galls.

"Of this 932 866,053 galls. were pumped against an average domestic pressure of 40 lbs. per square inch at the pressure gauge in the pumping station, which is equivalent to a lift of 108 ft. from the level of the water in the wells; and 11,606,694 galls. were pumped against an average pressure of 85.16 lbs. at the gauge, equivalent to a lift of 217 ft. from the surface level of the water. The average lift of all the water pumped was 110.4 ft.

"The number of fire alarms received at the pumping station was 99, and the works were run under fire pressure 63 hours and 48 minutes.

"The greatest quantity of water pumped in one day was 4,067,855 galls., August 19; during nearly one hour of this day, the works pumped at the rate of more than 8,000,000 galls. in 24 hours, with only the Gaskill and quadruplex engines in operation. The least quantity of water pumped in one day was 2 187,922 galls., November 28."

Steam Dredging Gear.—The accompanying illustrations show an ingenious and novel apparatus employed in dredging or moving material in earth cuts, patented in this country and abroad by Mr. S. N. Knight and J. P. Lambing, of California, and made by Knight & Company, engineers and millwrights at Sutter Creek, Amador County, Cal.

The "grab," as it may be called, is shown empty and expanded in fig. 1. In fig. 2, it is shown closed buried in the earth, and filled ready for hoisting. The apparatus consists of six or more strong hinged leaves or shovels linked to the cross head of a powerful steam piston seen on top, so the leaves are forced into material that could not be worked with the common clam-shell dredge buckets. The engraving is taken from the grabs forming a part of the plant at the Arroyo Seco Mine near Ione, in Amador County, where the workings are as peculiar as they are extensive. They consist of deep open cutting in the bed of a stream, and the operations are not different from deep cuts made for railways or other work. The grab is 6 ft. in diameter and 11 ft. high over all, and although made of wrought iron and steel throughout, weighs 3 700 lbs. when ar-

FIG. 1

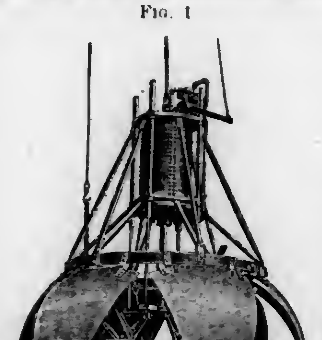
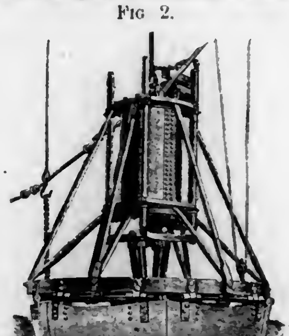


FIG. 2.



ranged for gravel and hard working, and lifts $2\frac{1}{2}$ tons at a load. The steam cylinder is of wrought iron 22 in. in diameter, with a stroke of 30 in., and will exert a pull of more than 30,000 lbs., which, with the gravity of the machine, gives a penetrating force of more than 16 tons, enough to penetrate material of almost any kind except solid rock.

The boom on which the grab is swung is 110 ft. long, swings through 180°, and delivers a load in $1\frac{1}{2}$ to 2 minutes' time, from 20 to 30 ft. high. In one modification proposed by Knight & Company, the boom swings through a complete circle, and consequently can load cars behind, when making a cut. In working under water the grab cylinders can be operated by air instead of steam.—*Industry, San Francisco.*

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NEW YORK, AUGUST, 1890.

IN connection with the table for Spiralizing Curves, sent by Mr. Franklin Riffle, Chief Engineer of the Oregon & Washington Railroad, and published in the JOURNAL for June, page 248, the fact should have been mentioned that the principles upon which the table are based are discussed in the book on Railroad Spirals, by Professor D. M. Greene, Troy, N. Y. The omission was accidental, and there was no intention to deprive Professor Greene of all due credit.

THE official trial of the *Philadelphia* over a 40-mile course at sea has shown that she is capable of making a speed of close upon 20 knots an hour and of keeping up that speed for a considerable time, making her one of the fastest, if not the fastest, cruisers of her size in existence. This result reflects great credit on her designers and builders, and will earn for the latter a considerable premium over the contract price. This result is based entirely on speed and not on power developed.

IN accordance with his expressed wish and the desire of the Swedish Government, the body of the late Captain John Ericsson is to be taken to his native country for final interment. In fitting recognition of his services the United States Government has detailed the war-ship *Baltimore* to carry his remains across the Atlantic. It is very seldom that such honors are paid to one who in his lifetime held no public office, but was simply a private citizen ; but in Captain Ericsson's case no one can say that the honor thus given to his memory was not deserved.

EXPERIMENTS WITH LOCOMOTIVE BOILERS.

A REPORT has recently been published in the *Bulletin* of the International Railroad Congress of some very interesting experiments which have been made by M. A. Henry, Chief Engineer of the Paris, Lyons & Mediterranean Railroad, to determine the best conditions for economy in locomotive boilers having different lengths of tubes, with fire brick and also with water-arches. A special boiler was built with the same fire-box as is used on the passenger locomotives of that road, and with the tubes of the same diameter, = 2 in. The length of the tubes could be changed from 6½ ft. to 23 ft. if desired. To accomplish this, the boiler was formed of a series of rings which could be bolted together to produce any length desired. The boiler had 185 tubes, 2 in. outside diameter.

In making the experiments the draft was produced by a blower, and, excepting that required to feed the blower, the steam produced was allowed to escape into the atmosphere. The water was carefully measured and the ashes were collected after each trial from the grate, ash-pan, fire-box, tubes and smoke-box and weighed. Frequent analyses were made of the gases in the smoke-box, and their temperature was also measured. A water-gauge was placed between the ash-pan and smoke-box to measure the vacuum produced by the blower. Preliminary experiments showed that a vacuum of 1 in. of water is sufficient for a boiler of the type experimented with, with a light load, 1¾ in. under normal maximum conditions and 3 in. when working hard. It was also ascertained during the preliminary trials that it was best to charge the fire at the moment when the temperature of the gases began to diminish in the smoke-box, after having remained for a time at a maximum. An electric bell was therefore arranged in connection with the thermometer in the smoke-box, so that when the temperature began to fall the bell would ring, which was the signal for the fireman to charge the fire.

Besides the knowledge of the influence of the length of tubes, it was desired to ascertain the value of a long and a short brick arch, figs. 1 and 2, and also the Tenbrink water-arch or water-table, fig. 3. The fire-box of the boiler experimented with was made in such a manner that either the water-arch or the brick-arch could be used as desired.

Experiments were made with tubes varying from 3 meters (10 ft. nearly) to 7 meters (23 ft.), each with four series of trials ; that is, one each with the ordinary fire-box, with long arch, with short arch and with the Tenbrink water-arch. Each of these series of trials was made with the three different amounts of vacuum named above. Each trial lasted about three hours. Persons interested in locomotive construction will find these experiments of very great interest, as none have ever been made which are so complete or which have been made in so thorough a manner. It is not easy to get at their significance without careful study, as so many different conditions were involved in producing the results, which were all plotted in separate diagrams. In order to explain the scope of the experiments, we have plotted on one diagram, fig. 4, all those with a plain fire-box, so as to make a comparison of the results easier and clearer. Having these clearly in mind, the effect produced by the brick and water-arches will be more easily understood.

In the diagram, $E\ F$ at the bottom represents a tube 23 ft. long, and the vertical lines above it represent different lengths of tubes which were experimented with ; the figures 3 m., 3.50 m., 4 m., etc., represent meters, and the scale below feet. The horizontal lines and the figures at each end indicate different quantities, which will be explained further on.

The experiments were made to determine first the quantity of coal which could be burned with various amounts of draft produced by the blower. The vacuum thus produced was measured by columns of water 1 in., 1¾ and 3 in. in height. The coal burned under these conditions with

different lengths of tubes is represented in the diagram by the three curves *A* 1 *A* 1, *A* 2 *A* 2 and *A* 3 *A* 3, all drawn in dark heavy lines. To explain the significance of these curves we will first take the lower one, marked *A* 1, which represents the coal consumed per hour with a vacuum of 1 in., and with tubes of 3, 3.50, 4, 4.50, 5, 6 and 7 meters in length, or very nearly equal to 10, 11½, 13¼, 14¾, 16½, 19¾ and 23 ft., as shown by the scale at the bottom of the diagram. In relation to these curves the spaces between the horizontal lines and the figures at each end of them represent hundreds of kilograms = 220 lbs. of coal burned per hour, and the vertical distance 3 m. to *A* 1 of the curve *A* 1 above the base line *A F* represents the quantity of coal = 466 kilos. burned in a plain fire-box, with tubes 10 ft. long and a vacuum in the smoke-box measured by 1 in. of water. The vertical distance 3.50 *a* shows the quantity = 462 kilos. burned with tubes 3.50 meters or 11½ ft. long. In the same way the height of the curve above the base-line *E F* on the vertical lines 4 m., 4.50 m., 5 m., etc., represents the quantities of coal burned per hour with tubes of the lengths indicated by the figures. The figures on the vertical scale on the right-hand side of the diagram represent the quantity of coal burned per hour in hundreds of pounds.

It will be seen from this curve that, as the length of the tube is increased, the quantity of coal burned, with a draft due to a vacuum of 1 in., diminishes and falls from 1,025 lbs. with tubes 10 ft. long to less than 800 lbs. when they are increased to 23 ft.

The curve *A* 2 *A* 2 represents the coal consumed with a draft due to a vacuum of 1¾ in. From this it will be seen that with this amount of draft and tubes 10 ft. long the coal consumed per hour is increased from 1,025 to 1,430 lbs., and from 800 to 1,108 lbs., with 23 ft. tubes. The increase with the greater draft is almost uniform for the different lengths of tubes. The same remarks will apply to the curve *A* 3, which represents the coal burned with 3 in. of vacuum.

It will thus be seen that the quantity of coal burned is largely dependent upon the draft, a fact which is well known, and that it is diminished by increasing the length of the tubes, which it might have been surmised would be the case, but which has never been so clearly shown before.

The curves *B* 1, *B* 2 and *B* 3, represented in dotted lines, show the quantity of water evaporated per hour in the same way and under the same conditions as the coal was burned. In relation to these curves the figures at the ends of the horizontal lines represent thousands of kilos., and those on the vertical scale on the right-hand side of the diagram represent thousands of pounds. From these curves it will be seen that when the length of the tubes was increased beyond 10 ft. that the quantity of water evaporated was greater, although the coal burned was then less. The water evaporated reached its maximum with tubes between 14 and 15 ft. long. As might have been anticipated, the most efficient length of tube is somewhat greater with a strong than with a light draft. These curves show the importance of adequate length of tubes.

The curves *C* 1, *C* 2 and *C* 3, drawn in light lines at the top of the diagram, represent the quantity of water evaporated per unit of coal burned. The figures at the ends of the horizontal lines in this case may represent either kilos. or pounds, and show either how many kilos. of water are evaporated per kilo. of coal, or how many pounds of water per pound of coal. It will be seen that the curve representing the effects of a light draft is above, and that of a strong draft is below, thus showing that the quantity of water evaporated per pound of coal is greater with a light than with a strong draft. The effect of the length of the tubes on the evaporation per unit of fuel is also made very plain from these curves. The economy increases very rapidly with the length of the tubes from 10 up to about 15 ft., and from there up to the limits of the experiments it continues to increase, but not at so rapid a rate.

The curves, *D* 1, *D* 2, *D* 3, represented by light lines at the bottom of the diagram show the temperature in the smoke-box. The figures at the ends of the horizontal lines in this case represent hundreds of degrees Centigrade. These curves show that this temperature diminishes with the draft and is reduced by increasing the length of the tubes, and that the rate of reduction is greater from 10 to 15 or 16 ft. than it is after that.

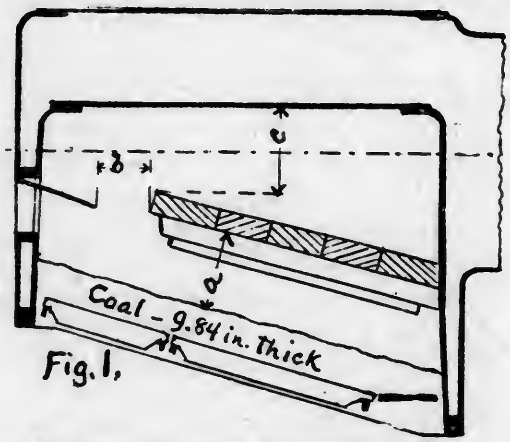


Fig. 1.

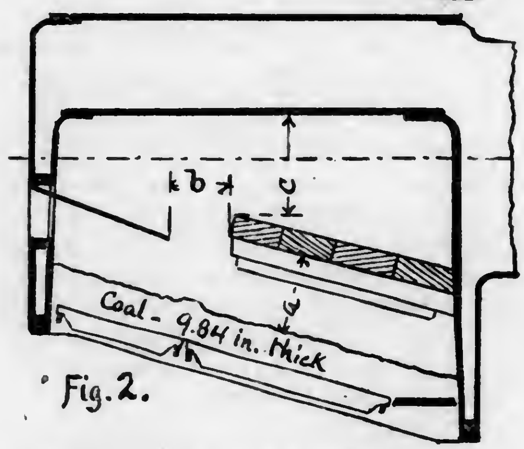


Fig. 2.

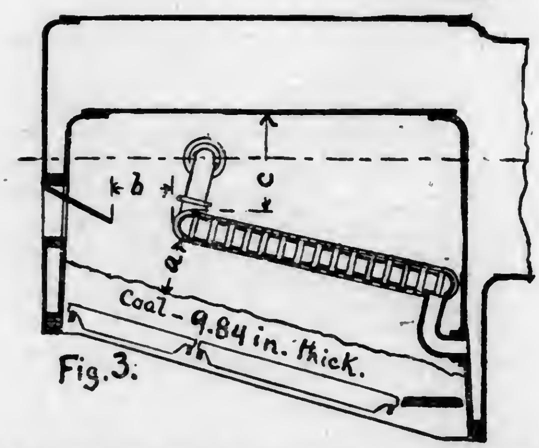


Fig. 3.

It was also shown, by collecting and weighing the cinders, that "in general, the long tubes result in a larger amount of cinder for a moderate vacuum than the short

tubes. For a strong draft the difference is much diminished, and it is not easy to distinguish any difference in the amount of cinders with a strong draft, whatever be the length of tube. The draft influences almost directly the quantity of cinders produced, and within the limits of the experiments made the cinders are sensibly proportioned to the vacuum or draft."

With a plain fire-box, the stronger the draft the less perfect was the combustion, but the influence of the length of the tubes on the completeness of the combustion appeared to be inappreciable.

To determine what would be the effect of reducing the number of tubes, some of them were stopped up. It was found that the coal burned and water evaporated per hour decreased as the number of tubes was decreased or stopped, but in a somewhat less proportion than that of the number of tubes suppressed. The economy of the boiler remained about the same.

The amount of water evaporated increases with the rate of combustion, but less rapidly.

The experiments with the brick and water-arches showed that the amount of coal burned per hour was diminished when they were used. The quantity of water evaporated per hour was increased with long tubes and diminished with shorter ones. The arches also increased the economy, or the water evaporated per pound of coal, but this increase was less with long than with short tubes, and with a moderate draft ranged from 6 to 12 per cent., according to the length of tubes, being greatest with tubes 10 ft. long. This economy diminished when the draft was increased.

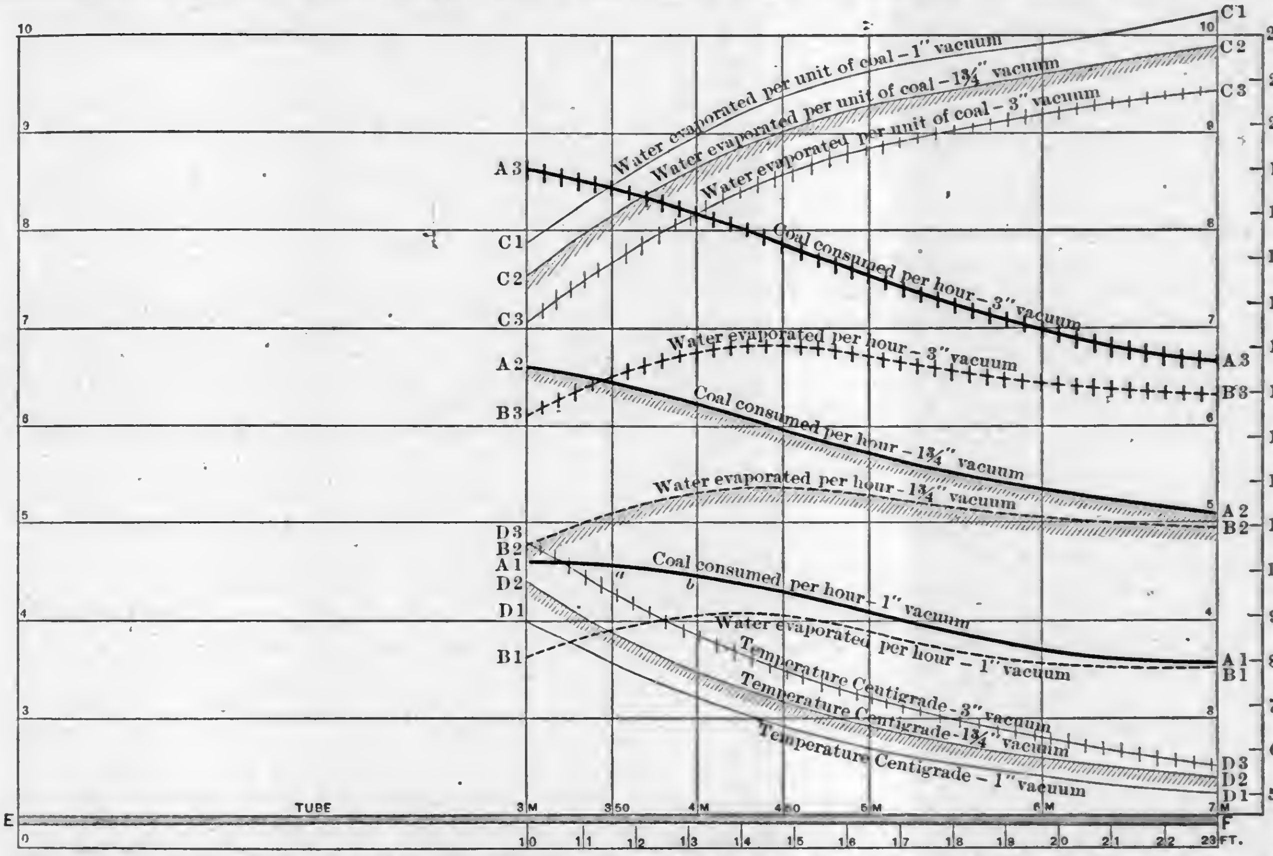
The quantity of cinders was reduced very much by the arches, amounting to as much as 45 per cent. in some cases. They also gave a more complete combustion, and the volume of air used and the temperature in the smoke-box was less.

The important questions to be considered in regard to locomotive boilers are, first, their capacity, or the rapidity with which they will generate steam, and, second, their economy. With reference to the first, the experiments showed that the brick-arches diminished the capacity of the boiler from 2 to 10 per cent., and the water-arch increased it in some cases as much as 5 per cent. All the arches increased the economy of the boiler. This economy varied from 6 to 12 per cent., being greatest with short tubes and a strong draft.

The conclusions drawn by the experimenters are in favor of the use of either a brick or a water-arch; of tubes from 12½ to 14 ft. in length, and as many of them as can be used within the limits of weight to which the locomotive is confined. They also say that "a variation in the vacuum is the best means of giving to the locomotive a wide range of power, and to enable the regulation of that power to suit sudden demands made upon the engine." For that reason they suggest the use of a variable exhaust. It should be noted that the length of tubes recommended applies only to those 2 in. in diameter, as they were the only ones experimented with. The experiments are being continued, and they may throw some light on the question of the effect of various diameters of tubes.

As already remarked, the experiments are very interesting and throw much needed light on the question of the most efficient and economical length and number of tubes. The rate at which coal is burned has, however, much to do with the proportions of tubes. The maximum amount of coal burned during these experiments was 1,900 lbs. per hour. As the grate had an area of 24.2 sq. ft., the rate of combustion was 78½ lbs. per foot per hour. On another page will be found a report of experiments made on the Baltimore & Ohio Railroad, showing rates of combustion of 133.2, 148.1 and 193.1 lbs. per sq. ft. per hour, or more than double the maximum rate of the experiments on the Paris, Lyons & Mediterranean Railway. This comparison shows, what has been known before, that locomotives in this country are worked much harder than they are worked

Fig. 4.



in Europe, and the question very naturally arises whether the lengths of tubes which were found to be best suited for burning coal at the rate of 78½ lbs. per square foot per hour would be the best for burning more than double that quantity.

In the light of the experiments there is, however, room for dissent from the conclusions which have been drawn in favor of the use of brick or water-arches. It is admitted in this respect that brick-arches diminish the steam-producing capacity of the boiler, and the water-arch increases it about 3 per cent. This percentage is just about equal to the proportion that the heating surface of the boiler is increased by the arch, and doubtless the addition to its capacity is due to that cause. It would appear to be very much cheaper, and less expensive in maintenance, to simply enlarge the boiler to get a needed increase of capacity, rather than to add the water-arch.

With reference to economy, it was shown that this benefit was greater when the tubes are shorter and the draft more energetic. If this is the case it would again seem to be better to lengthen the tubes and to lessen the draft by enlarging the boiler, so that for a given amount of steam production the fire would not require to be stimulated so much. In other words, the experiments seem to show that the advantages attributed to brick and water-arches could be realized by simply making the boilers larger.

It would be extremely interesting if the scope of the experiments was extended, so as to throw some light on the most economical area of grate for given rates of combustion. In this particular there is much diversity in locomotive practice, and it seems probable that the proportions of the grate have a greater influence on combustion and the economy of the boiler than those of any of its other parts.

THE NEW CROTON AQUEDUCT.

WATER from the Croton Dam was let into the new aqueduct on July 15 for the first time, and has been running through its entire length since. After running for a few days the water was shut off to permit a careful examination, but it is now in regular use. It has been five years under construction.

The length of the aqueduct proper is 30.75 miles, from Croton Lake to the gate-house at One Hundred and Thirty-Fifth Street in New York City. From that point to the main reservoir in Central Park, 2.37 miles, it is continued by a system of iron pipes, so that the total distance from Croton Lake to the reservoir is 33.12 miles. The length in tunnel is 29.63 miles, and 1.12 miles are in open trench.

From Croton Lake to a point near Jerome Park the aqueduct is oval in section, 13.53 ft. high and 13.6 ft. wide, and its estimated capacity is 318,000,000 gallons daily. At that point a large reservoir is to be built to supply the northern part of the city. South of that point the section is circular, 12.25 ft. in diameter, and its total capacity 250,000,000 gallons daily. At the lower gate-house the water is transferred to 12 iron pipes, 48 in. in diameter.

Blow-outs for emptying the tunnel are provided at four points, where the aqueduct comes near the surface. The deep valley of the Harlem River is crossed by an inverted siphon, formed by two shafts and a tunnel under the river. At this point the tunnel is 307 ft. below tide-water level and is reduced to 10.5 ft. in diameter, as the water will pass through under considerable pressure. The total fall from Croton Lake to One Hundred and Thirty-Fifth Street is 25 ft.; from the gate-house to the Central Park Reservoir, 34.4 ft. The average fall in the aqueduct proper is 0.7 ft. per mile.

In building the aqueduct there were 42 shafts sunk, the depth varying from 22 to 420 ft.—the last-named was at the shaft where the tunnel passes under the Harlem. The total cost has been about $23,600,000, to which some additions are still to be made.

In connection with the aqueduct three dams—the Sodom, the Titicus and the Amawalk—are now being built, to form additional storage reservoirs. The yearly supply from the Croton watershed is sufficient for the city, but the storage capacity is not great enough to retain it until it is needed, in the dry season. The system can hardly be considered complete until the great Quaker Bridge Dam is built, when an ample and steady supply at all seasons will be secured.

A PROPOSED SHIP CANAL.

A NEW plan for a ship canal connecting Philadelphia and New York is proposed by Professor Lewis M. Haupt. The proposed line leaves the Delaware at Bordentown, N. J., follows the line of the Delaware & Raritan Canal for 1¾ miles, then runs due north, striking the old canal again north of Trenton and using it for 9½ miles more. It then leaves the present canal finally, crosses the divide near Dean's Pond and follows the line of Lawrence Brook to the Raritan River below New Brunswick.

The highest point on the proposed line is 76 ft. above tide-water. The greater part of the canal would be on one level, 50 ft. above tide water, which would be reached by two locks of 25 ft. lift each, at each end of the level. These, with the tide-lock at each entrance, would make six locks in all; the plan makes these 500 ft. long, 60 ft. wide and 20 ft. deep over the sills.

The section proposed for the canal is 20 ft. depth, 90 ft. width at bottom and 150 ft. at the surface. The supply of water along the line is abundant, and there would be no difficulty in keeping the summit level full for any probable traffic and number of lockages. The total distance from Bordentown to the Raritan River is 33¾ miles; the estimated work is about 26,318,000 cub. yds., with about 350,000 cub. yds. of dredging at the terminals. There would be no rock cutting or very expensive work, but 31 bridges over the canal would be needed, as its line crosses 5 railroads and 26 highway roads.

Professor Haupt estimates the total cost at about $12,553,000, excluding right of way.

NEW PUBLICATIONS.

HAND-BOOK OF PASSENGER TRAFFIC AND ACCOUNTS: BY MARSHALL M. KIRKMAN. Chicago; published for the Author.

This is another volume of Mr. Kirkman's well-known series on Railroad Accounts. It treats of the transportation of passengers; of regulations governing the handling of passengers at stations and on trains, and of the ticket accounts of railroads. It also includes a large number of forms for passenger business, based upon long experience of the requirements of a large railroad system. The Author's general plan and method can be best explained by quoting his own preface:

The principles that underlie the operations of carriers are

alike everywhere. Their methods of doing business, however, are never the same. But definite knowledge of one renders it easy to acquire knowledge of another. It is this that makes descriptive books valuable. Through them the student may obtain a glimpse of railroad work generally; a clew to the labyrinth, without which knowledge cannot be acquired except by a lifetime of laborious practice, and then only disjointedly. This is the object of this book—as it is of the series of books of which it forms a part. I do not write for experts, for men whose minds are made up, but for the young; for those who still have something to learn; for those who desire to learn.

Mr. Kirkman does not insist upon uniformity of accounts, believing it to be impracticable and undesirable, on account of the great diversity in local circumstances and the requirements of different railroad lines. He has written his book, therefore, as a hand-book of reference and instruction, not as an absolute system of rules. Viewed in this light, it will be of great service to railroad accountants; and the numerous forms given will serve very well for models where they cannot be copied or used just as they are given. It covers the field of passenger traffic accounts very thoroughly, and those who are concerned in that subject can hardly read it without gaining some new ideas.

United States Geological Survey. Monograph No. XV; the Potomac or Younger Mesozoic Flora: by William Morris Fontaine. Part I, Text; Part II, Plates.

United States Geological Survey. Monograph No. XVI; the Paleozoic Fishes of North America: by John Strong Newberry.

Bulletins of the United States Geological Survey. No. 54, On the Thermo-Electric Measurement of High Temperatures. No. 55, Report of Work done in the Division of Chemistry and Physics. No. 56, Fossil Wood and Lignite of the Potomac Formation. No. 57, A Geological Reconnaissance in Southern Kansas. Washington; Government Printing Office.

This group of publications of the United States Geological Survey reaches us too late for much critical comment; it can only be said now that in general form and execution they are fully up to the high standard generally reached by the Survey. The Bulletin on Thermo-Electric Measurement of High Temperatures is of especial interest.

In this connection it may be noted that a very unwarrantable attack recently made in Congress on the Geological Survey and its methods can best be refuted by the results attained by the Survey and by a simple statement of the work which it has accomplished. It is hardly a secret that this attack has been prompted by interested motives, and that behind it are parties who have planned to absorb for their own profit sources of water supply which would give them a vast water monopoly and consequently the virtual control of a great part of the irrigable lands of the West. These men have found that the work of the Survey on irrigation and the publicity given to it has seriously interfered with their plans; and they have tried to use Congressional investigation as a means of revenge, or to compel a measure of compliance with their designs. They can hardly be successful, and their total failure is much to be desired.

Eighth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1886–87. Parts I and II: J. W. Powell, Director. Washington; Government Printing Office.

This report gives a very careful and complete statement of the methods pursued by the Geological Survey in the various departments of its work in the field and in the office, showing how the work is subdivided and the system adopted in carrying it on. Necessarily there are many things to be considered in so extensive a range of subjects as that committed to the charge of the Survey, and system is necessary. The statement of what was done during the year covered by this report shows how great the work is and over how much ground it extends.

Besides the general report and statements, the two volumes include a number of special reports. Among these are monographs on the geology of the Mono Valley and the Lassen Peak in California; on the Trenton Limestone as a source of Petroleum and Natural Gas; on the Quicksilver Deposits of the Pacific Slope; on the Geology of Mount Desert Island, Me., and on the Geographical Distribution of Fossil Plants.

The report shows great progress in the topographical surveys which are carried on under the direction of the Survey, and which are a necessary part and accompaniment of its work. Much progress was also made in the office work connected with these topographical surveys, in the preparation and publication of the maps based upon them.

Preparations were also made for beginning the geologic map of the United States, and much consideration was given to the plan on which this map is to be prepared. The devising of such a plan, which shall be uniform for the whole country, is no easy matter, and requires much care and consideration. The advantages of uniformity can readily be seen, but it is difficult to devise a system by which it can be obtained in such a way as to make the maps of the greatest possible service to those who will use them.

Geological Survey of New Jersey: Final Report of the State Geologist. Volume II, Part I.

Volume I of the State Geologist's Final Report related to the topography and climate; Volume II treats of the mineralogy, botany and zoölogy of the State, Part I containing lists of the minerals and plants found within its limits. Both the lists are long, for there are few States which have so widely diversified a surface, with a comparatively small area, as New Jersey, and few that have such a variety of minerals. Indeed some localities in the State are famous throughout the scientific world.

The volume is a continuation of the final summing up of the work of the Survey, which is now approaching completion.

Geological Survey of New Jersey: Annual Report of the State Geologist, 1889: Irving S. Upson, Assistant in Charge. Trenton, N. J.; State Printers.

The office of State Geologist of New Jersey has not been filled since the death of Professor George H. Cook, but the work has continued under the Assistant in charge, Mr. Irving S. Upson, who has been long connected with it and is thoroughly familiar with Professor Cook's methods and plans. During 1889 the Geological Survey of the State was continued, while in the office the publication and distribution of the first volume of the Final Report was completed, the second volume was prepared for publication, and work begun on the third and fourth volumes.

The work of the New Jersey Geological Survey has always been of a high order, and has been of great value to the State. Much of this was due to the ability and enthusiasm of Professor Cook, who had charge of it from the beginning, and it is evident that the assistants whom he has trained will not permit the standard set by him to be lowered.

The present report contains special reports or chapters on the Geodetic Survey by Professor E. A. Bowser; the Archæan Rocks, by Frank L. Nason; Studies of the Triassic and Trap Rocks; Drainage in the Pequest and the Passaic Valleys, by George W. Howell; Water Supply and Artesian Wells, by C. C. Vermeule; with the statistics relating to the progress and expenses of the Survey, and statistics of the production of iron and zinc ores.

The output of iron ore, it may be noted, was 482,169 tons, an increase over 1888, but a decrease from 1887 and 1886. The

highest point ever reached in the State was in 1882, when 932,762 tons of iron ore were mined. The output of zinc ore in 1889 was 56,154 tons, the largest ever reported, and an increase of 23 per cent. over the previous year.

GRUNDSÄTZE FÜR DEN ABSCHLUSS VON EISENBAHN TARIFCARTELLEN (PRINCIPLES OF THE FORMATION OF RAILROAD RATE AGREEMENTS): BY HERR EMIL RANK, CHIEF OF BUREAU OF THE AUSTRIAN NORTHWESTERN RAILROAD. Vienna, Austria; published by A. Hartleben.

This work is intended, in the first place, as a discussion of the question whether railroad traffic agreements are to be recommended, either from the point of view of the railroads themselves or of the public generally and if this question can be answered in the affirmative, to consider what are the causes of the evils which, it is claimed, traffic agreements have introduced into railroad management. It is intended to consider all those factors which disturb and interfere with the service, and to formulate the principles upon which agreements should be made, basing these on the result of experience. Some consideration is also given to other questions, and especially to that class of agreements which are intended to control the business of districts producing large amounts of traffic.

Some idea of the scope of the book may be gained from the subjects treated in it, which include: Agreements for the Division of Business; Securing Business for Different Routes; Fixing Tariffs under Agreement; Handling of Unbilled Freight; Uniform Division of Profits; Proceeding in Case of Business Disagreements; Right of Mutual Control; Decision of Disputed Questions; Duration of Traffic Agreements; Agreements for Mutual Control of Production Districts.

The subject is treated with the thoroughness which we often find in German works upon this subject, and with much more regard to general principles than we are likely to find in this country. It is well worth the attention of those who are interested in this subject.

SPON'S ENGINEERS' DIARY AND REFERENCE BOOK, FOR ENGINEERS, MACHINISTS, CONTRACTORS AND USERS OF STEAM. London and New York; E. & F. N. Spon.

This has been prepared for English rather than American engineers, the information which it contains being of English trades and markets, the lists of societies English, and the calendars essentially English in their arrangement. About one-quarter of the book is filled with tables of weights, measures, etc., addresses of societies, calendars, reports of markets and similar matter; the remainder is occupied by a calendar having a good space for each day in the year, upon which a memorandum record can be kept. This occupies alternate pages, the intervening pages being given up to advertisements. The diary is convenient; but the book is rather too bulky for daily use.

THE WHITNEY CONTRACTING CHILL: BY JOHN R. WHITNEY, PATENTEE. Philadelphia; published by the Author.

This neat little pamphlet is a brief but forcible—and more forcible because brief—presentation of the merits of the contracting chill and the advantages of its use in casting car-wheels. There has been some discussion of the merits of this device, but the question is, perhaps, one best settled by experience and the actual results obtained from wheels cast in contracting chills. There are certainly many arguments in its favor, and a strong one—which is not mentioned in the pamphlet—is that it has been adopted by wheel-makers of such high standing and long experience as the Messrs. Whitney.

BOOKS RECEIVED.

PROCEEDINGS OF A NATIONAL CONVENTION OF RAILROAD COMMISSIONERS, HELD AT THE OFFICE OF THE INTERSTATE COMMERCE COMMISSION, WASHINGTON, MAY 28 AND 29, 1890. Washington; issued by the Interstate Commerce Commission.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; published by the Institution. The present installment of these papers includes Telephonic Switching, by Charles Henry Wordingham; Building in Earthquake Countries, by John Milne; Deep Water Quays in the Port of Cork, by Philip Barry; Taking the Temperature of the Cylinder Walls of a Steam Engine at Different Depths in the Metal, by Bryan Donkin; Water Works in China and Japan, by J. W. Hart, James Orange and J. H. T. Turner.

A second installment includes papers on the Action of Quicksands, by Wilfrid Airy; Concrete Quarters for Native Staff on Indian Railroads, by Thomas Ker; Reclamation of Lake Aboukir, by H. G. Sheppard; Barry Dock Works, by John Robinson; Lough Erne Drainage, by James Price; three papers on bridges—the Hawkesbury Bridge, by C. O. Burgi; the Dufferin Bridge over the Ganges, by F. T. G. Walton, and the Blackfriars Railroad Bridge, by G. E. W. Cruttwell.

PRACTICAL SANITARY AND ECONOMIC COOKING: BY MRS. MARY HINMAN ABEL. THE LOMB PRIZE ESSAY. Published by the American Public Health Association.

REPORTS FROM THE CONSULS OF THE UNITED STATES TO THE STATE DEPARTMENT. No. 115, APRIL, 1890. Washington; Government Printing Office.

EIGHTEENTH ANNUAL REPORT OF THE PENNSYLVANIA COMPANY, FOR THE YEAR ENDING DECEMBER 31, 1890.

QUARTERLY REPORT OF THE CHIEF OF THE BUREAU OF STATISTICS, TREASURY DEPARTMENT, ON THE IMPORTS, EXPORTS, IMMIGRATION AND NAVIGATION OF THE UNITED STATES, FOR THE THREE MONTHS ENDING MARCH 31, 1890. Washington; Government Printing Office.

THE ECONOMY AND EFFICIENCY OF STEAM HEATING AT ATMOSPHERIC PRESSURE: THE BARNARD VACUUM SYSTEM FOR HEATING BUILDINGS BY STEAM WITHOUT PRESSURE. New York; issued by the Barnard Engineering Company.

THE MAYRHOFER ELECTRO-PNEUMATIC SYSTEM FOR DISTRIBUTING STANDARD TIME. New York; issued by the Electro-Pneumatic Time Company.

EFFICIENCY OF CHAIN BLOCKS: REPORT BY PROFESSOR R. H. THURSTON. Stamford, Conn.; issued by the Yale & Towne Manufacturing Company.

CATALOGUE OF THE CINCINNATI CORRUGATING COMPANY, CORRUGATED AND OTHER SHEET METAL BUILDING MATERIAL. ILLUSTRATED. Piqua, Ohio; issued by the Company.

ABOUT BOOKS AND PERIODICALS.

THE JOURNAL of the Military Service Institution for July has articles on Infantry Battle Tactics, by Captain McClernand; Reform in Army Administration, by Lieutenant-Colonel Lee; Place of the Medical Department, by Lieutenant-Colonel Woodhull; Fifth Corps Ambulance Train in 1864, by Lieutenant-Colonel Drum. There are also a number of translations and reprints of interest, and an historical sketch of the Fourteenth Regiment of Infantry, by Colonel T. M. Anderson.

Among the notable articles in the POPULAR SCIENCE MONTHLY for July are Telpherage in Practical Use, by F. A. Fernald; Meteorites, by Dr. O. W. Huntington; Commercial Geography of South America, by G. G. Chisholm, and Greenland, by Elisée Reclus.

In SCRIBNER'S for July, which is a summer number, Mr. Bruce Price's article on the Suburban House will be found excellent reading. The article of the Citizen Series for the month in on the Right of the Citizen to his own Reputation, and is by E. L. Godkin. Surf and Surf Bathing, by D. Osborne, is hardly a scientific article, but will interest a good many at this season.

Besides the usual excellent assortment of literary matter, BELFORD'S MAGAZINE for July contains an article on Storms and Earthquakes, by Dr. Felix L. Oswald, and one on Sexagesimals and the Origin of Hours and Minutes, by James McCarroll.

The WESTERN ENGINEER for June—published by the Pond Engineering Company—has a very practical article on Steam Boilers for Stationary Power, by William Lowe, which is worth reading.

Reference has heretofore been made to the Lomb prize essays of the American Public Health Association. The prize this year was awarded to an essay on Practical Sanitary and Economic Cooking, as adapted to persons of small and moderate means. The essay was written by Mrs. Mary Hinman Abel, who has fairly earned the prize by a very good and practical treatise, which the Association has just published in book form.

An account of the presentation of portraits of Generals Grant, Sherman and Sheridan to the United States Military Academy at West Point, by Mr. George W. Childs, of Philadelphia, has been issued in a very neat pamphlet form. It is prefaced by some very interesting personal recollections of General Grant by Mr. Childs, who was, as is well known, a very intimate friend of the great commander.

EXPERIMENTS SHOWING THE RATE OF COMBUSTION IN LOCOMOTIVES ON THE BALTIMORE & OHIO RAILROAD.

EXPERIMENTS were made some time ago on the 17-mile grade of the Baltimore & Ohio Railroad by George B. Hazlehurst, now General Superintendent of Motive Power of that line, to show the maximum quantities of coal burned per square foot per hour in the grates of locomotives. The grade referred to begins at Piedmont, and has an ascent of about 117 ft. per mile for 17 miles. This grade is often combined with sharp curves, so that it is a continuous hard pull for the whole distance, and it gives an excellent opportunity of making a test of the quantity of fuel which can be burned in locomotive grates.

One experiment was made with a ten-wheeled engine and a train weighing 352,000 lbs. The running time was just 60 minutes, and the total coal consumed was 3,391 lbs. = 148.1 lbs. per square foot of grate per hour.

A second test was made with the same engine on September 20, 1889. Total weight of train, 380,000 lbs.; running time, 67 minutes; coal consumed, 3,809 lbs.; consumption per square foot of grate per hour, 133.2 lbs.

In both of these tests there was a dry rail and an average steam-pressure of 143¾ lbs. The dimensions of the engine were as follows: Weight in working order, 114,500 lbs.; on driving-wheels, 91,000 lbs.; cylinders, 19 × 24 in.; diameter of driving-wheels, 60 in.; total heating surface, 1,899 sq. ft.; size of grate, 33 × 100 in. = 22.9 sq. ft.; diameter of tubes, 2 in.

Another test, still more remarkable, was made with an American type of engine. The weight of the train was 378,900 lbs.; coal consumed, 5,316 lbs.; coal consumed per square foot of grate per hour, 193.7 lbs.; running time, 59 minutes.

While the last experiment was made the rail was dry; the average steam pressure was 148.1 lbs.; the dimensions of this engine were: Total weight in working order, 107,700 lbs.; weight on driving-wheels, 73,400 lbs.; cylinders, 20 × 24 in.; diameter of driving-wheels, 66 in.; total heating surface, 1,511 sq. ft.; size of grate, 34 × 120 in. = 28.3 sq. ft.

The coal used on these engines was broken gas coal from the Pittsburgh Division of the road, part of it having been in the tender some time. The experiments were made by running the distance from Piedmont to Altamont, about 17 miles. There can be no doubt of the accuracy of the tests, and they show that the maximum rate of combustion in locomotive fire-boxes is considerably greater than is ordinarily supposed. Rankine gives this rate, "with draft produced by a blast-pipe or fan," at 40 to 120 lbs. per square foot per hour. The latter amount has generally been accepted as the maximum quantity burned. Probably 200 lbs. of coal are often burned per square foot per hour in locomotives in this country.

EXPERIMENTS ON THE TEMPERATURE IN LOCOMOTIVE SMOKE-BOXES.

BY REUBEN WELLS.

THE experiments recently made on the Paris, Lyons & Mediterranean Railroad, to determine the variations in economy of locomotive boilers with different lengths of tubes, and which are discussed in an editorial on another page, will give a special interest to some investigations made by Mr. Reuben Wells some years ago on the Jeffersonville, Madison & Indianapolis, of which he was Superintendent of Machinery at that time. Through the courtesy of Mr. Wells we are enabled to give an engraving of the diagrams which he made to represent the results of his investigations. In his experiments the temperature in the smoke-box was taken from a pyrometer every quarter minute, and the steam pressure was taken simultaneously. In the diagrams the spaces between the vertical lines represent minutes and the spaces between the upper horizontal lines represent 20° of temperature. The spaces between the horizontal lines at the lower part of the diagrams represent 10 lbs. of steam pressure per square inch.

The wavy lines at the top represent the temperature observed in the smoke-box of different engines, as will be explained later on, and the steam pressure is shown by similar lines at the lower part of the diagrams.

The experiments were made as follows:

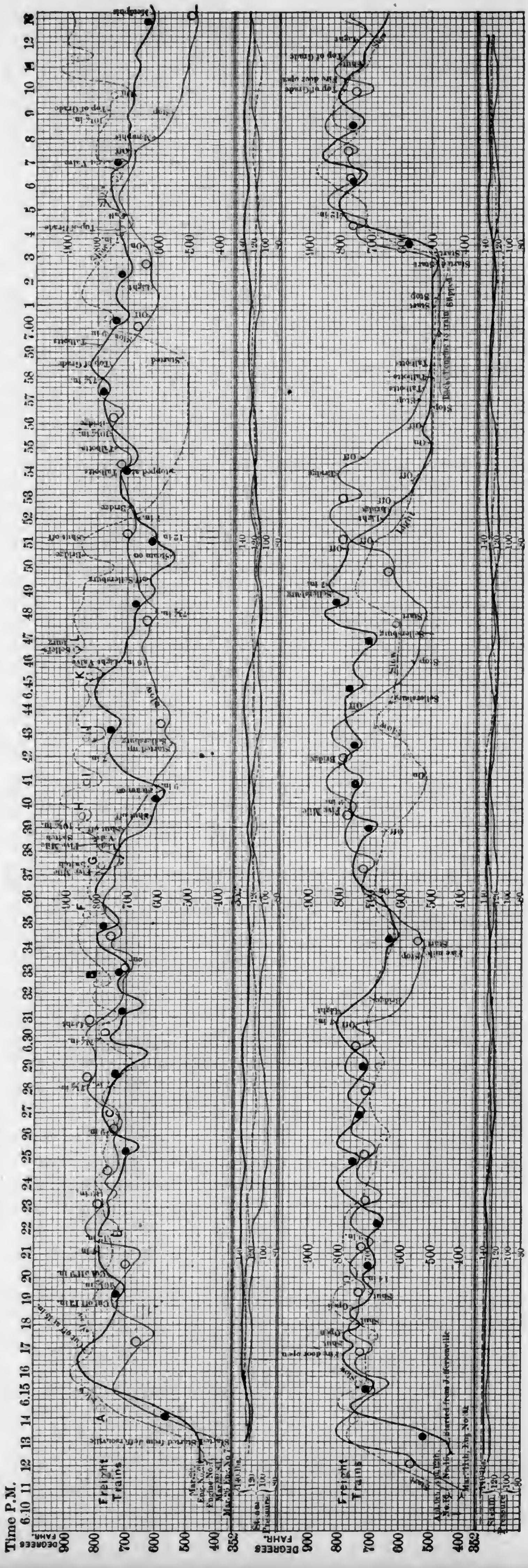
FIRST EXPERIMENT.—Was made on March 22, with engine No. 7, which had 16 × 24-in. cylinders, 5-ft. driving-wheels. The boiler had 114 tubes 2 in. diameter and 11 ft. 2 in. long; 70½ sq. ft. of heating surface in the fire-box and 636⅓ in the tubes, making a total of 707 sq. ft. The train consisted of 26½ loaded freight cars. The average speed was 16 miles per hour. The average steam pressure was 117 lbs. Size of exhaust nozzles, $2\frac{7}{16}$ in. The temperature in the smoke-box is represented by the upper dotted line in fig. 1, and the steam pressure by the dotted line below.

SECOND EXPERIMENT.—Made March 26, with same engine, with 26½ loaded freight cars (three empty cars being rated as two loaded). The average speed while using steam was 17.5 miles per hour; average temperature in the smoke-box, 721° Fahr.; average steam pressure, 114 lbs.; exhaust nozzles, double, $2\frac{1}{16}$ in. diameter. The evaporation on a run of 432 miles and an average train of 28.2 loaded cars was 5.54 lbs. of water per pound of coal, equal to 2.71 lbs. per car per mile. The temperature and steam pressure for this engine are represented in fig. 1 by light lines.

THIRD EXPERIMENT.—Made March 29, with engine No. 28, with 16 × 24-in. cylinders and 5-ft. wheels. The boiler had 153 2-in. tubes, 10 ft. 10 in. long; 90 sq. ft. of heating surface in the fire-box and 830 in the tubes, or a total of 920 sq. ft. The weight of the water in the boiler was 7,000 lbs. The train consisted of 29 loaded freight cars; the average speed while using steam was 14.52 miles per hour. Average temperature in smoke-box, 712°; average steam pressure, 128 lbs. Exhaust nozzles $2\frac{5}{16}$ in. diameter. The evaporation on a run of 432 miles and an average train of 30.71 loaded cars was 6.20 lbs. of water per pound of coal, or equal to 2.17 lbs. per car per mile. The temperature and pressure are represented in fig. 1 by a heavy line.

FOURTH EXPERIMENT.—Made April 9, with engine No. 16, with 17 × 22-in. cylinders and 5-ft. wheels; exhaust nozzles, 3 in. diameter. The boiler had 158 2-in. tubes, 11 ft. long; 96 sq. ft. of heating surface in the fire-box, 868 in the tubes, making a total of 964 sq. ft. The train consisted of 27 loaded freight cars; average speed while using steam, 19.35 miles per hour. Average steam pressure, 129 lbs. Average temperature in smoke-box, 714°. The temperature and pressure are indicated by dotted lines in fig. 2.

FIFTH EXPERIMENT.—Made April 11, with engine No. 30, with 14 × 22-in. cylinders, 5-ft. wheels, and 2⅜-in. exhaust nozzles. The boiler had 113 2-in. tubes, 10 ft. 11



in. long ; $77\frac{1}{4}$ sq. ft. of heating surface in the fire-box, $616\frac{1}{2}$ in the tubes, or a total of 694 sq. ft. Weight of water in boiler, 5,600 lbs. The train consisted of 21 loaded freight cars ; the average speed while using steam was 16.5 miles per hour ; average temperature in smoke-box, 739° ; average steam pressure, 124 lbs. The evaporation on a run of 432 miles and an average train of 22.12 loaded cars was 6.07 lbs. of water per pound of coal, or 2.70 lbs. of coal per car per mile. The temperature and pressure are indicated by light lines in fig. 2.

SIXTH EXPERIMENT.—Was made April 12, with engine No. 16, with freight train of 30 loaded cars. Average speed, 16.46 miles per hour ; average temperature in smoke-box, 734° ; average pressure, 129 lbs. The temperature and pressure are indicated by heavy lines in fig. 2.

The circles on the lines or curves which represent the temperature indicate when the furnace door was opened. The solid black circles refer to the dark lines there represented in outline to the light lines, and those which are dotted to the dotted lines, and the figures along the curves indicate the inches of cut-off of the valves.

Taking the experiment of March 22, and it will be seen that in starting from Jeffersonville the temperature in the smoke-box was 360°, and the steam pressure was 126 lbs. Immediately after starting the temperature began to rise, and in four minutes it reached 885°. At *A* the furnace door was opened, but the temperature continued to rise. At *B* it was again opened, and it will be seen that it was succeeded by a fall in temperature, and that was followed by a rise. At *D, E, F, G, H, I, J, K* and *L* the furnace door was opened, and in each case it will be seen a fall of temperature followed which was succeeded by a rise. In all the diagrams this sequence is noticeable. It will be seen though, that the furnace door is not usually opened until after the temperature begins to fall, which is perhaps indicated by the steam-gauge. The opening of the door and the consequent admission of cold air carries the temperature still lower until the combustion of the fresh fuel carries it up again.

Where the dotted line in fig. 1 crosses the $51\frac{1}{2}$ vertical minute line it will be seen that steam was shut off. The temperature was then 840°. It immediately began to fall, and when the engine stopped at 54 minutes it had fallen to 560°, and before starting went as low as 500°. The effect of starting again at $58\frac{1}{2}$ minutes is again obvious in the rapid rise of temperature. These remarks will apply to all of the diagrams. Our engravings represent only a portion of those which Mr. Wells plotted. The highest temperature shown on the diagrams is 995°, although the portion which we have had engraved shows only 920°.

Mr. Wells also made similar experiments with passenger engines. In these, as might be expected, the variations in the temperature are somewhat more sudden than in the freight engines.

He also experimented with a stationary boiler with natural draft. The changes in the smoke-box temperature were not nearly through so wide a range nor so sudden as in a locomotive boiler. The highest temperature was less than 800°, and the average during 53 minutes was, with coal for fuel, 620°, with 87 lbs. average pressure. While burning wood during 65 minutes the average temperature was 651° and the pressure 87 lbs.

He also made an experiment to show the rate of increase of temperature in the water in boiler, while firing up engine No. 16, with the following results :

Starting fire....		60°.			
In 30 minutes,		175°.			
" 55	"	250°.			
" 70	"	275°.			
" 75	"	295°.	Steam commenced to show at the whistle.		
" 85	"	310°.	"	7 lbs.	
" 90	"	330°.	"	15 "	
" 95	"	340°.	"	22. "	
" 100	"	350°.	"	30 "	

If the steam pressure had been represented in the diagrams on a larger vertical scale, the relation between it and the temperature in the smoke-box could have been seen more clearly. The experiments are very interesting, and show very clearly the variations which occur in the temperature due to our present imperfect method of firing.

A FRENCH ARMORED CRUISER.

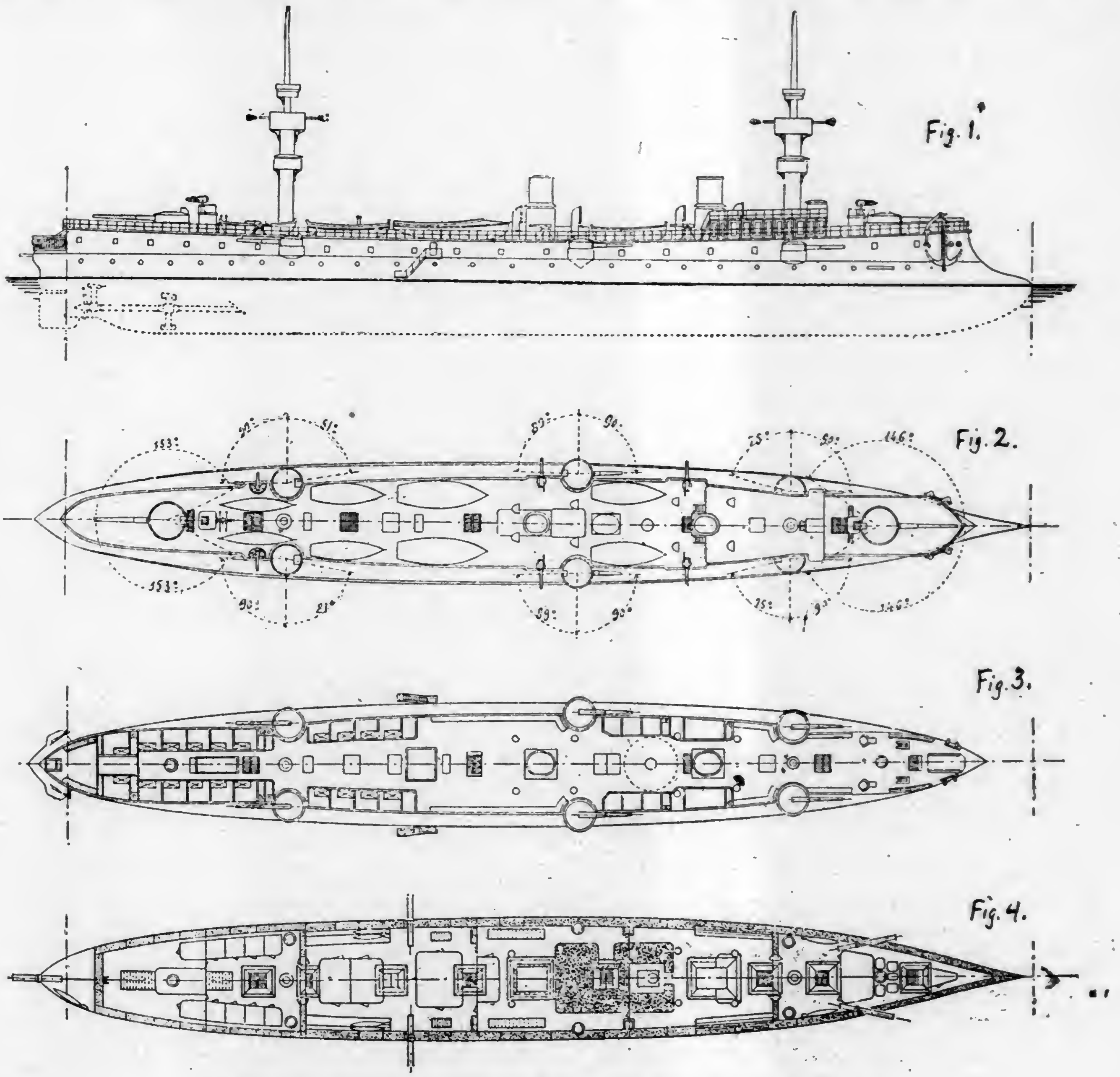
The accompanying illustrations, from *Le Yacht*, show the plans adopted for the new armored cruiser *Charner*, which is rated as of the second class in the French Navy. These plans have just been completed and the construction of the vessel begun.

The plans were made by M. Thibaudier, and the principal dimensions of the ship are as follows: Length between perpendiculars, 106.00 m. (347.68 ft.); maximum width, 14.00 m. (45.92 ft.); mean draft of water, 5.84 m. (19.15 ft.). The total displacement is 4,745 tons, the weight being distributed as follows: Hull and armor, 2,858 tons; machinery and boilers, 713 tons; artillery, 278 tons; materials and ammunition, 896 tons.

The hull is of steel, the stem being of forged steel and the stern-post of cast steel. The keel is in the form of a double girder and is composed of two plates of steel joined by two angle irons at each side. The plates are spaced 10 cm. (3.93 in.) apart, and the angles are joined together in the form of the letter Z. The space between the two plates is filled in with teak. There are 14 water-tight compartments between the keel and the armored deck, and between the armored deck and the upper deck the ship is divided into six compartments. Provision is made for the use of water ballast.

The armored deck is of the turtle-back form, which has been adopted in a number of French vessels. The plates are 5 cm. (1.96 in.) thick in the center, diminishing to 4 cm. (1.57 in.) at the sides.

The armor belt which covers all the vital parts of the ship is 92 mm. (3.64 in.) thick and is bolted to a backing of 18 mm. (0.70 in.), which is considered heavy enough to stop shells loaded with high explosives. The protection in the neighborhood of the water-line is completed by coffer-dams filled with cellulose, which rise to a height of 1.20 m. (3.93 ft.) above the water-line, and which have a thickness of 1.10 m. (3.60 ft.). They rest at the bottom on the armored deck and are shown in fig. 4, given herewith.



ARMORED CRUISER "CHARNER," FOR THE FRENCH NAVY.

Fig. 1 in the accompanying illustrations is an elevation of the ship; fig. 2 a plan of the spar deck; fig. 3 a plan of the lower deck, and fig. 4 of the armored deck.

The armament of this ship consists of two guns of 19 cm. (7.48 in.) caliber and 8.50 m. (27.88 ft.) length; six guns of 11 cm. (4.33 in.) caliber and 4.20 m. (13.77 ft.) length; four rapid-fire guns of 65 mm. (2.53 in.), four rapid-fire guns of 47 mm. (1.85 in.), and six Hotchkiss

guns of 37 mm. (1.45 in.). There are besides five torpedo tubes. The 19-cm. (7.48 in.) and the 14-cm. (5.51 in.) guns are enclosed in turrets mounted on pivots which descend to the lower deck.

There are two military masts of steel, each composed of an exterior cylinder 1.70 m. (5.57 ft.) in diameter and an interior cylinder 0.50 m. (1.64 ft.) in diameter, carrying above a light mast for signals. Between the inner and the outer cylinders is a double ladder for ascent and descent. Each mast is supplied with three platforms, the lower one serving as a lookout, while the second is a small turret carrying a rapid-fire gun of 47 mm. (1 85 in.) caliber ; the third platform is a redoubt for riflemen. The other two 47-mm. guns are mounted on the spar-deck.

The motive power will consist of two independent triple-expansion engines, each driving a bronze screw of 4.35 m. (14.26 ft.) diameter and 5.05 m. (16.56 ft.) pitch. These engines are intended to develop 8,300 H.P. with forced draft, or 7,600 H.P. with natural draft, and the speed expected is 19 knots an hour with forced draft, and 17 knots with natural draft. Steam will be furnished by 16 Belleville boilers arranged in groups of four, in four separate compartments. The valves of the engines are all piston-valves and the valve motion is of the Marshall type.

The normal coal capacity is 400 tons, and with this supply the cruising range will be 3,000 knots at a speed of 12 knots, or 4,000 at a speed of 10 knots an hour.

This is one of four similar ships, two of which, the *Charner* and the *Bruix*, are to be built at the Government Works at Rochefort ; the other two are to be built by contract, the *Chanzy* by the Société de la Gironde at Bordeaux, and the *Latouche-Treville* by the Société des Forge et Chantiers at Havre. They will cost about $900,000 each.

TUBULOUS BOILERS.

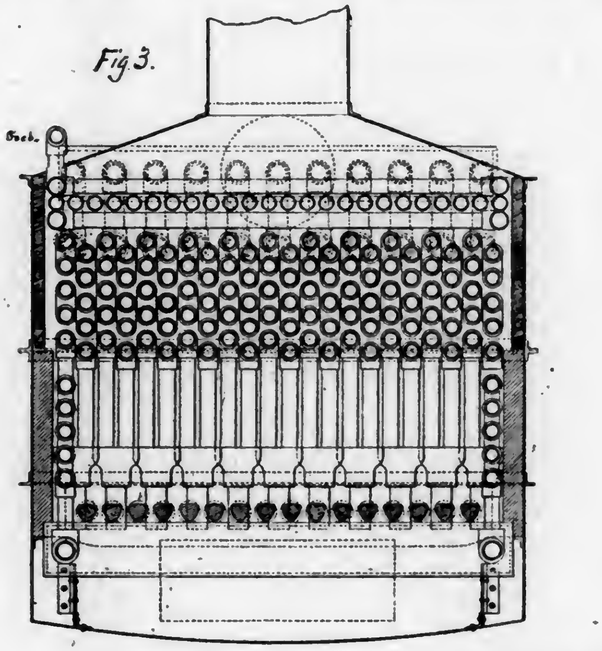
(Paper read by Assistant Engineer S. H. Leonard, U. S. N., before the American Society of Naval Engineers, and published in the *Journal* of the Society.)

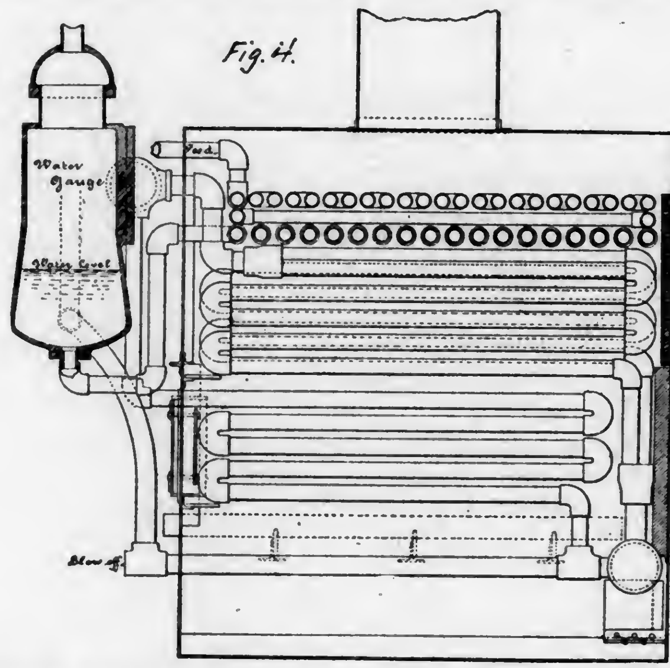
(*Concluded from page* 321.)

THE HERRESHOFF BOILER.

THIS boiler, shown in figs. 3 and 4, consists of a number of vertical elements, each composed of horizontal tubes, with right and left-hand threads, and connected by return bends. Two adjacent elements are connected at the back and lower ends by short vertical tubes to a Y-piece, which has a short connection to a mud-drum situated below the grate bars. At the upper ends the same elements are similarly connected to a steam-drum situated just in front of the boiler casing. At each side of the grate there is an element having a connection to the steam-drum, and another to the feed-water pipe near the mud-drum. These side elements and the vertical connecting pipes to the mud-drum serve like water-legs to protect the boiler casing from the intense heat of the fire. Above the boiler proper and entirely within the casing there are three horizontal elements forming a practically continuous pipe, the tubes of which are connected to each other as in the vertical elements. These elements serve as a feed-water heater and also protect the top of the casing by reducing the temperature of the gases of combustion. In front and at the upper part of the boiler is the centrifugal separator, from the top of which the main steam pipe leads to the engine, and at about the middle of which the steam-drum is connected.

The upper element of the feed-water heater receives the main feed-pipe, the lower element being connected to the bottom of the separator. All the tubes of this boiler and the feed-water heater are of iron, and are separately tested before they are put in the boiler to a pressure of 1,000 lbs. per square inch. The U-connections are of malleable cast-iron, carefully selected.





THE HERRESHOFF BOILER.

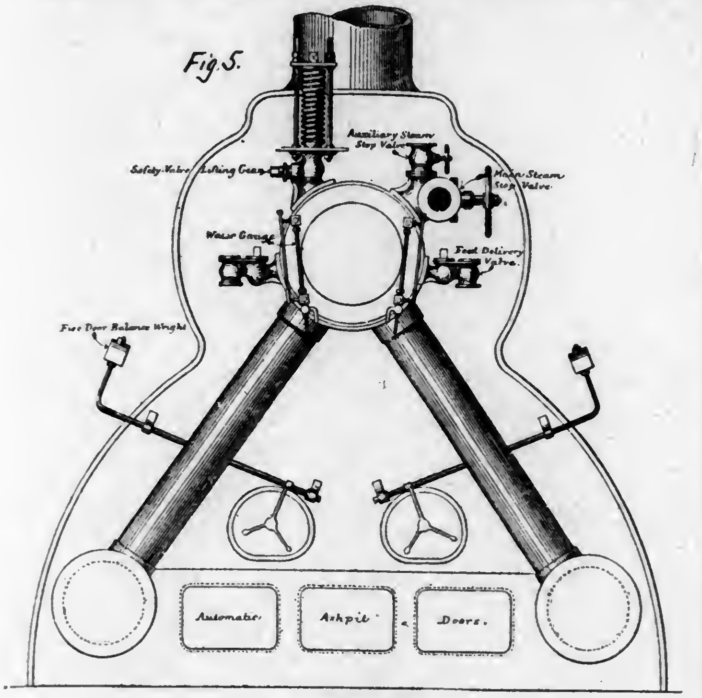
The circulation is as follows : The feed-water enters the upper horizontal element at the point marked "Feed" on the plate ; forced through these elements by the feed-pump, it enters the bottom of the separator, and from there, by means of two downcast pipes attached to the sides of the former near the bottom, it passes to the lower water chamber or mud-drum at the back of the boiler ; this mud-drum supplying in turn the several vertical elements, which finally discharge into the side of the drum, and thence the steam, together with any intermixed water, passes into the centrifugal separator, to the top of which the steam-pipe is attached. The lower side elements draw their supply from the connecting pipes between the downcasts. and mud-drum, and discharge into the bottom of the steam-drum, there meeting the discharge from the vertical elements. This design of boiler looks toward a complete, or nearly complete, conversion of the water into steam before it reaches the steam-drum. The object of this later design is to produce a boiler which will not require as close attention to the feed supply as did the original Herreshoff coil boiler.

THE THORNYCROFT BOILER.

This boiler, shown in figs. 5, 6 and 7, consists of a horizontal drum or separator at the top, placed longitudinally over the center of the grate ; two smaller horizontal cylinders on either side of the grate, a number of steam gener-

ating tubes, connecting the upper part of the circumference of the smaller cylinders with that of the separator, and of two downcast pipes outside of the furnace, connecting the separator with the wing cylinders, these pipes being for the sole purpose of supplying water to the wing cylinders. The greater number of the generating tubes

Fig. 5.



to the top of the drum is placed the dry-pipe leading to the stop-valve on the front of the boiler. The wing cylinders are protected from the direct heat of the furnace by the fire-bricks, which form the sides of the grate. In case of a tube giving out, it can be readily plugged from the inside of the drums, and as the heating surface is relatively large in this type of boiler, quite a number of the tubes could be so treated without seriously impairing the efficiency of the boiler.

THE TOWNE BOILER.

This boiler is of rectangular box form, as shown in figs. 8 and 9. It is provided with a steam-drum or separator, which is connected with the boiler proper at the top by means of downcast pipes. The horizontal tubes are screwed into the drum, as shown, and expanded in the tube sheets. These latter are bent or inclined to meet the generating tubes, which make an angle of 30° with the vertical. The spacing of these tubes will be readily understood from the plate. The screw plugs in the boiler shell permit of any defective tube being readily removed. These plugs are slightly greater in diameter than the tubes, in order to permit the use of an expander. The plugs are so made that in case they become set from any cause they can be readily broken if necessary to remove them. The drum is fitted with baffle-plates, as shown, and is protected on its lower side by the generating tubes, and on its upper side by a coil of piping acting as a feed-water heater.

The feed enters the front of the boiler casing, near its top, and after passing through the feed-heating coil, emerges again and enters the front head of the separator, below its water level. From here, by means of downcast pipes, the water passes to the bottom of the boiler, thereby supplying the generating tubes, which in turn carry it to

Fig. 6.

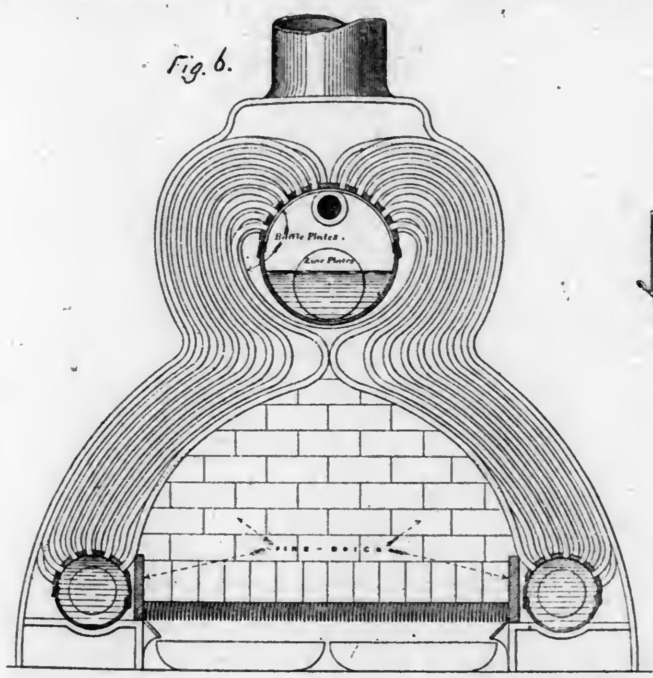
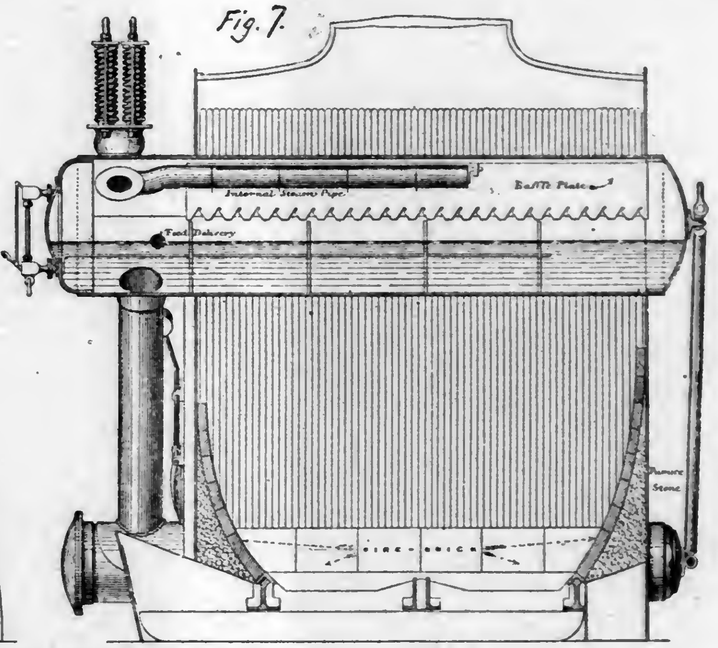


Fig. 7.



THE THORNYCROFT BOILER.

are arranged as shown in continuous full lines in fig. 7, those in full lines in fig. 6 being only the groups at each end of the boiler, which are so arranged for the purpose of protecting the ends of the casing. The separation of the steam and water is effected by a semicircular baffle-plate placed inside the separator at its upper end, and upon this plate the steam and its contained water is discharged from the generating tubes.

The circulation is as follows: The feed-water enters the lower part of the separator at the front end of the boiler, thence passing to the downcast pipes at the back, it is led to the wing cylinders, which in turn supply the generating tubes. These latter discharge into the upper semi-circumference of the steam-drum or separator, the steam and water impinging directly upon the curved baffle-plate previously mentioned. Directly beneath this baffle-plate and close

the top of the box section again, and thence, by means of the horizontal connecting tubes, it passes to the separator. From the top of the separator the steam passes to the main steam pipe, after passing through a baffle-plate.

THE WARD BOILER.

This boiler, in its general form, is a vertical cylinder, as shown in fig. 11. Radiating from either side of a central vertical drum, is a row of vertical steel columns, placed at an angle of 180° apart; these columns on one side of the drum rest on a horizontal manifold, their upper ends being closed; the vertical columns on the opposite side are connected to horizontal manifolds at top and bottom. These three manifolds are connected to the central drum at their inner ends.

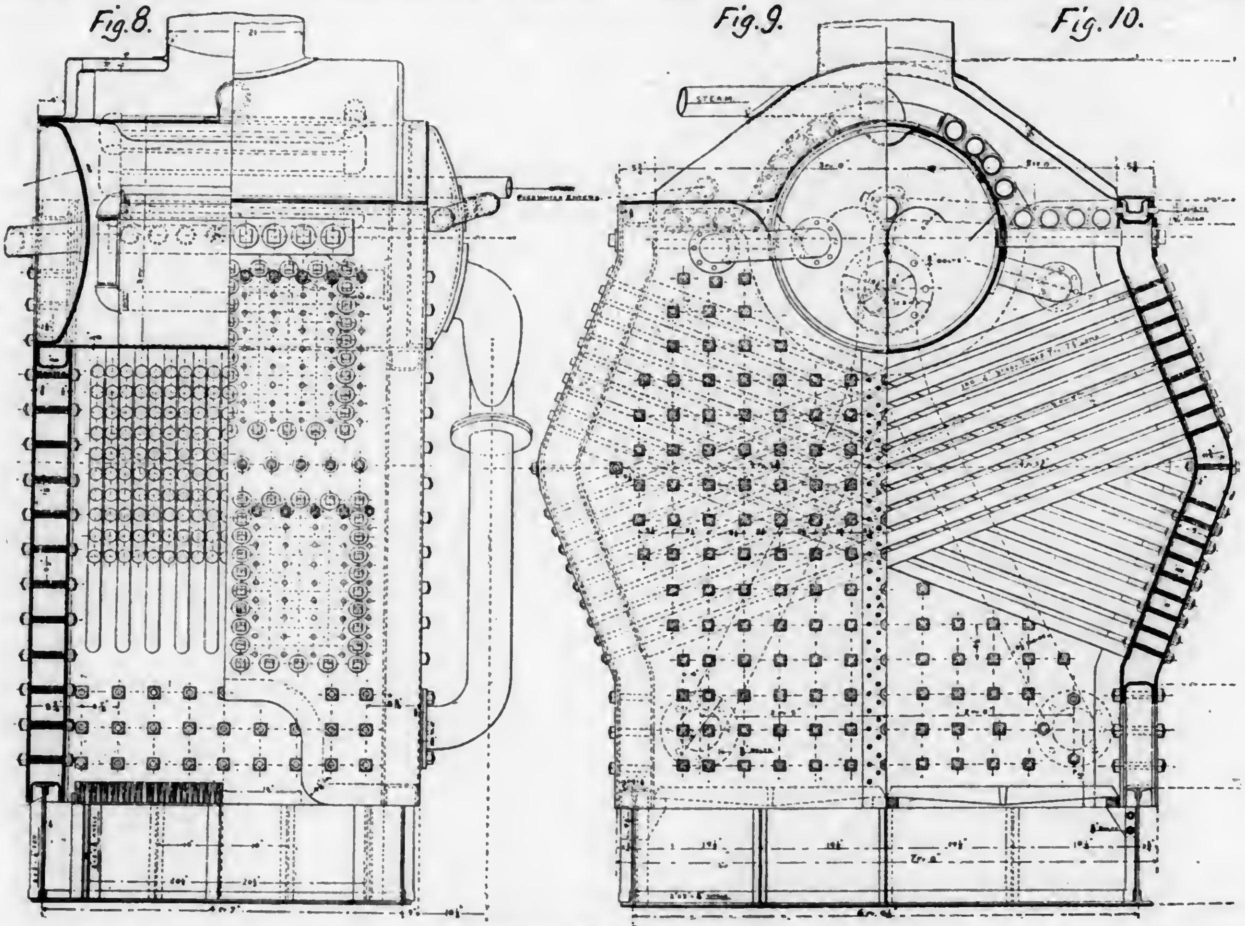
In a plane, slightly inclined to the horizontal, are a large

number of concentric tubes, each completing a semi-circumference ; there are the same number of concentric sections or nests of these tubes as there are vertical water columns. The tubes are secured to the vertical columns ly means of steel bushings, with right and left-hand threads and thus a defective tube can be readily removed.

The feed-water enters the base of the vertical drum, and is conducted by an internal pipe (having an inverted " rose" on its end) to about the water level in the boiler ; from here it passes down the drum to supply the horizontal manifolds *C* and *P ;* from manifold *P*, water passes to the vertical water columns *E E E*, which in turn supply the horizontal tubes ; these latter discharge into the vertical columns *H H H*, and, together with the steam formed in these columns, flow to the upper manifold *I*, and thence to the upper part of the central drum ; the steam, after passing through a baffle-plate, enters the dry-pipe *J* leading to the stop-valve. Any water entering the drum with the steam falls again and completes the circuit.

In this boiler every individual piece is free to expand and contract independent of any other.

By removing the top of the boiler casing and the upper manifold *I*, any of the nests of tubes may be *raised* out of the jacket for examination or repairs.



THE TOWNE BOILER.

THE WARD LAUNCH BOILER.

This boiler, shown in fig. 12, has recently been fitted to some of our navy launches, and is also in general form a vertical cylinder, but is radically different in its general arrangement of pipes from that of the large Ward boiler.

From a horizontal annular manifold, a double row of small water tubes rises vertical 3 ft. to 6 ft., according to the size of the boiler, and then taking an easy sweep of 90°, enters a central drum. In order to form the furnace door, a rectangular, hollow, vertical projection is cast upon the upper semi-circumference of the manifold. The interior of this projection is in connection with the interior of the manifold and contains water. Upon the top of the projection for the furnace door, and upon the upper surface of the manifold, nipples are placed alternately on different diameters, so that the nipples of one row come opposite the spaces between the nipples of the other row. Into these nipples the lower ends of the two rows of vertical tubes, forming the sides of the furnace, are secured by screw-couplings. The upper ends of the tubes are secured into nipples, cast on the central drum, by screw-couplings, in the same manner as the lower ends. Owing to the small circumference presented by the central drum, there is not sufficient space for it to receive the tubes of the same row on the same horizontal plane ; accordingly, each alternate tube of each row enters the drum on a lower plane than the remaining tubes.

The central drum consists of two portions, namely, the lower, filled with water, and the upper, filled with steam, the upper portion being a vertical extension of the lower. Both are cylindrical, and have their axes in the same vertical line with the axis of the boiler. The lower portion of the drum is of cast steel, $\frac{5}{8}$ in. thick, and upon its sides are cast the nipples into which the upper ends of the tubes are screwed. Its bottom is an inverted right cone, into which are screwed concentric rows of wrought-iron hanging tubes. The open top of these hanging tubes has a wrought-iron plug, perforated with two holes, fitted tightly into it and held in position by friction. Each of these perforations is fitted with a seamless brass tube open at both ends. One of the tubes extends downward into the hanging tube to within one inch of the bottom of the latter ; the other extends upward 6 in. on its slant height above the bottom of the lower portion of the drum.

The two brass tubes are parallel with the hanging tube, to which they are attached. The plug acts as tube-plate for both.

The lower portion of the drum has an inclined partition carried entirely around it, partitioning off an annular pocket of triangular cross-section. This partition joins the vertical sides of the drum, just below the entrance of the outside row of tubes forming the sides of the furnace, and divides the water in the lower portion of the drum into two separate portions.

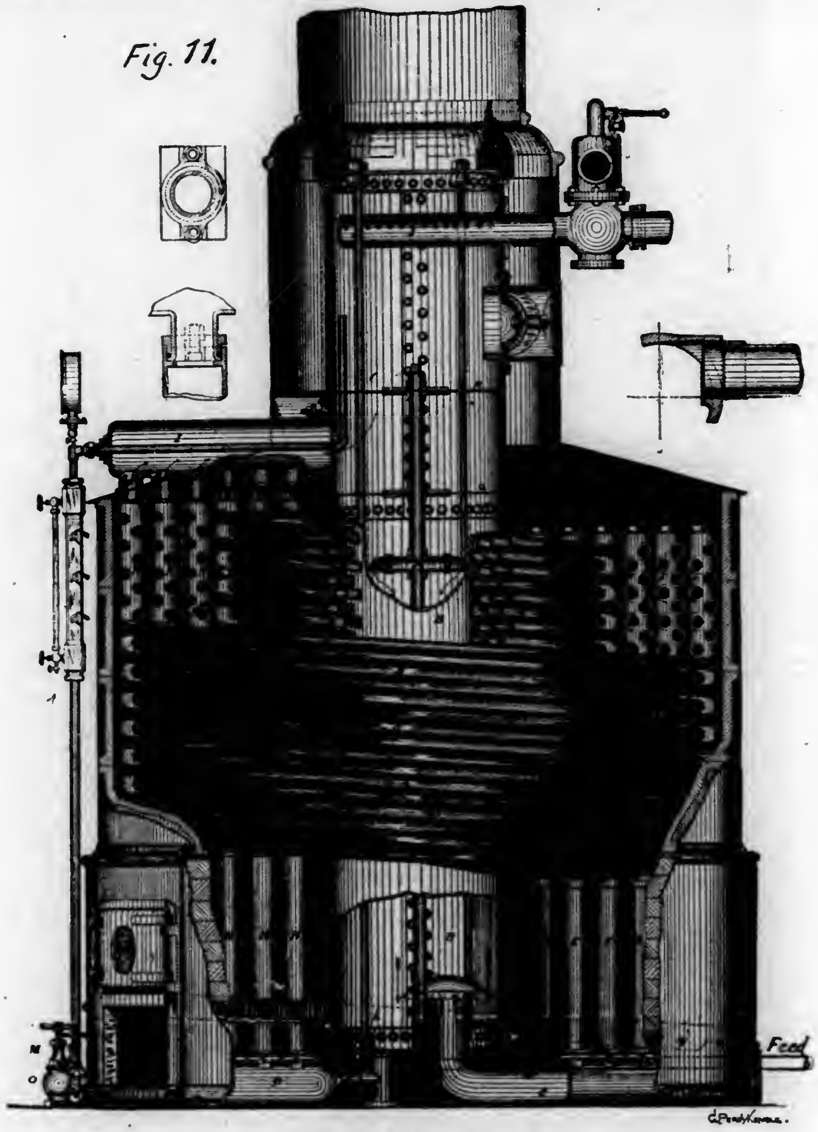
The feed enters a conduit formed by a semicircular lip turned over at the upper end of the partition, and from which it is delivered into the annular triangular cross-sectioned space formed by the partition and sides of the lower portion of the drum. From this space the water descends the *outer* row of tubes to the horizontal manifold or base-ring, from which it ascends again by means of the *inner* row of tubes into the lower portion of the drum.

The water enters the brass tube inside the wrought-iron hanging tube from the lower portion of the drum, and is delivered at the bottom of the hanging tube. The water then descends the latter, and is finally delivered from the upper end of the brass tube that is above the hanging tube into the lower portion of the drum.

The small quantity of water in the tubes relatively to their heating surface causes the circulation in this boiler to be very rapid.

The discussion on this paper showed a general opinion in favor of some form of tubulous boiler. Admitting the necessity of greater care and watchfulness and of frequent cleaning, it was still considered that the demand for higher pressures could be met by this class of boiler, and that the advantages in the diminished space and weight were undoubted. One member advocated the claims of the Belleville boiler, saying that it had hardly received fair treatment in the tests made.

It may be noted here that the Ward boiler has been adopted for the coast defense ship *Monterey*, now under construction at San Francisco, which is to have four of these boilers.



THE WARD BOILER.

THE WARD LAUNCH BOILER.

THE GERMAN TESTING STATION AT CHARLOTTENBURG.

(From *Industries.*)

SOME articles have been written lately respecting the various fuel-testing stations which have been established in Germany and elsewhere, and urging their adoption in England. With the penetration and scientific insight that distinguishes them, the Germans were among the first to perceive that the introduction of steam and machinery had revolutionized industry, and that it was, therefore, essential that the working conditions of a boiler, for instance, should be as perfect as possible. The relations between the steam and the combustible generating it having been determined, it has for many years been within the power of every coal consumer in Germany to have his fuel consumption tested at a small cost, and its heating value ascertained. And of late a fresh step has been taken. The Germans have succeeded in arranging for daily tests, on a large scale and by accurate scientific methods, of the strength and quality of iron, wood, steel, paper, oil, etc.—in short, of all materials used in machinery and construction.

About six years ago a testing station was established at Charlottenburg, under the auspices of the Prussian Government. The institution has been organized on a strictly scientific and commercial basis. A series of instruments have been devised, chiefly by the officials who conduct the tests, for carrying the trials out as perfectly as possible;

and a fixed scale of charges has been drawn up. Any manufacturer, wishing to have a product of his mill or factory tested, is supplied with a tariff of prices, a list of the different methods by which the article specified can be tested, and precise instructions regarding the proper size of the samples to be sent in. Although the establishment is still in its infancy, it will be seen at a glance how important a place it may hereafter occupy in commercial industry. All disputed questions between buyer and seller as to strength and quality of goods delivered can be settled at once, and the interests of both equally protected by an appeal to the authorities at Charlottenburg. A still more critical function is there performed, by testing with scientific precision the strength of the materials employed in bridges, buildings, etc.

The institution is under the superintendence of Herr Martens, a distinguished engineer. It is connected with the Technical and Mechanical High School at Charlottenburg, and has an engineering workshop attached to it, which forms an indispensable adjunct to the work undertaken, and a training school for the students. The substances tested are divided into four sections :

1. Metals, wood, ropes, driving-belts, chains, and all materials used in construction.
2. Lubricating oils.
3. Paper of all kinds.
4. Gauging and testing machines.

1. As may be supposed, the work done in the first division is the most important. The usual method of determining the strength of metal is to test sample bars of a given size, but the actual parts of any structure can also be experimented upon. The station possesses the appliances necessary to determine the resistance to tension, pressure, percussion, bending, twisting and buckling ; also the tensile strength of leather belts and cords, sheet iron and corrugated plates. Wire is tested for its bending and twisting capacity, oil for its lubricating properties, and paper for strength and quality of material. Iron and other metals are also tested by weights falling vertically ; and by an ingenious arrangement, to be described hereafter, these experiments can be carried out at a distance from the testing station. The tests applied are of two kinds : 1st, single experiments upon the tensile and ductile strength of the material ; 2d, repeated trials continued for a long time, and intended more especially to test for power of prolonged resistance. The metal bars generally used are from 1¼ in. in diameter upward. An ordinary simple test comprises : Determination of the limit of elasticity, breaking weight, the elongation of the metal, and diminution of area after fracture. Sleepers, girders and iron columns are tested for resistance to sudden pressure, and the limits of elasticity obtained. Samples of iron for carriage and locomotive axles are tested, under load and while revolving. The hardness of sheet iron and buckled plates, the strength of telegraph wires, and the tensile strength of wood, driving-belts, steel, iron and hempen ropes are also carefully proved and tested. To all these operations a regular tariff of prices is attached.

A complete trial of cast iron comprises the following processes : 1. Three separate tests of the resistance of the metal to bending. The size of the bars experimented on must be 3 ft. 7 in. × 1¼ in. × 1¼ in. 2. Tension and torsion tests, without determining the limit of elasticity, upon some of the bars already tested for bending. 3. Six pressure tests, made upon cubes 1¼ in. side, cut from bars already tested.

In even the smallest experiments it is desirable to test not less than five bars of a certain prescribed size, as the average quality of the metal cannot be determined from fewer experiments. If special strength and solidity are required more elaborate trials are necessary. By these tests two important points are ascertained : 1. The original quality of the materials used, and (2) the changes they undergo in the process of manufacture. The size of the bars experimented upon is a matter of much importance. The instruments for carrying out the tests are of course adapted for working upon material of a certain size, and are with difficulty adjusted differently. Tools for separating the portion to be tested from the rest of the metal are provided in the workshop of the station. It is so necessary that this portion should really represent the average quality of the material that the authorities prefer to have the metal sent in the rough, and to cut the test pieces from it themselves. The proper experiments for determining the limit of elasticity can only be carried out with bars of the standard size.

Testing the materials used in construction and in machinery is at present the most important function undertaken at Charlottenburg, and a large number of instruments are used for this purpose. Four machines, having a capacity respectively of 98 tons, 49 tons, 39 tons, and 1 ton, are employed to test the resistance of metals to tension, pressure, bending, breaking, etc. The two largest are worked by an automatic hydraulic accumulator, and are regulated by levers, screws, moving weights and springs. Wire up to one-third of an inch in diameter is tested in a small machine specially designed. Two machines for vertical pressure, one with a weight of 110 lbs. and a fall of 14 ft. 9 in., the other with a weight of about 1,350 lbs. and a fall of 32 ft., are used for sleepers, tires of wheels and axles. Measuring instruments, a furnace for testing the elasticity of red-hot iron, crucibles for alloys and cast iron, and a forge complete the appliances in this section of the station. Eleven machines of different types are used for repeated and long protracted experiments. In each of them from four to eight bars can be tested at the same time, and in other machines the bending of loaded bars is repeated continuously so many times per minute. Ropes, cords, driving belts and wood can also be tested in almost all these machines, and it is intended shortly to add appliances for percussion.

2. These, although the most important, are by no means the only experiments undertaken by the institution. Oil for lubricating machines is analyzed and tested under ordinary working conditions. Nothing, perhaps, is more essential to the proper driving of machinery than to determine the quality of the materials used to prevent friction. The chemical laboratory, which forms one of the chief departments of the station, here becomes of value. The oil is subjected to 12 tests. The most important are the determination of the specific gravity and visible properties of the oil, as color, transparency, iridescence, taste and smell ; its power of liquefaction at a temperature varying from 68° Fahr. to 302° Fahr.—for this the mean of 10 experiments is taken. The coefficient of friction for a given speed and pressure is also ascertained, as well as the point at which the oil congeals and burns. The boiling-point, the residuum after boiling, the quantity of acid contained, and the chemical analysis of the oil form part of the investigation. These experiments are easily and accurately carried out with various appliances, some of them automatic. Where a new vein of oil is struck, and it is desirable before working it to know the quality of the oil, the value of this systematic and scientific testing can scarcely be overrated.

3. Paper may be, and is, frequently subjected to the same exhaustive tests. All paper supplied to the Prussian Government must be tested and properly certificated before it is accepted ; the value of other paper is ascertained at the wish of the buyer or seller. For these experiments the paper is divided into two sections, comprising (1) strength of texture, and (2) quality of material used. Each section is subdivided respectively into six and four classes, and every kind of official paper must pass a certain standard prescribed by Government. In Section 1 the strength of the paper is tested according to a theoretical quantity called the "tearing weight." The weight required to break the paper is first ascertained, and then reckoned in so many thousand feet of paper of the same width. Thus the tearing weight of a first-class paper will generally be about 5,466 yards of paper. The paper is also tested for its elasticity, resistance to creasing and crumpling, material of which it is composed, and especially for any admixture of mechanical wood-pulp, which is rigidly excluded from the composition of all good paper. The tests usually applied to a paper are : Determination of its tearing weight and elasticity, of its resistance to friction and crumpling, quantity of ash left after combustion, chemical examination to detect wood-pulp if present, microscopical examination of the fibers and other materials

in the paper, and chemical analysis of the coloring matter, acids, chloride, etc., in the paper and sizing. The shape and quantity of paper to be sent in is fixed by the authorities, though it is not so strongly insisted on as in the case of metals.

4. A fourth branch of the institution, which has not yet assumed large proportions, is that of testing the instruments and appliances used to prove the strength of metal. These machines are either completely tested in all their parts, or the accuracy of certain important sections, as weights, scales of measurement, levers, etc., are carefully verified. Attached to this branch of the establishment is a department for enabling manufacturers to make practical use of those methods of testing which have here been reduced to a science. Small copper cylinders 2 in. in height and ¾ in. in diameter are sent, if desired, with a copy of the testing certificate. The cylinders are subjected to the same heavy vertically falling weight as the metal to be tested. Their power of resistance to pressure being accurately known, the effect produced on them is calculated, and the resisting strength of the iron deduced from it. This forms a simple and convenient method of testing iron. It obviates the difficulty and expense of conveying heavy blocks of metal to the testing station, while at the same time it ensures the same scientific accuracy as in the experiments there undertaken.

Another useful branch of the institution is devoted to photography. Views are taken of exploded boilers, broken bridges and other iron structures, and of large pieces of wrecked machinery, and afford a valuable record of the condition of the iron at the actual moment of fracture. Many of these interesting photographs were shown at the section allotted to the Charlottenburg Testing Station in the Berlin Exhibition of 1889. A valuable and instructive collection of objects was also exhibited, comprising fragments of iron from exploded boilers, the exact point in a girder where it had given way, the piece of defective metal which had caused the collapse of a building, together with models or photographs of the various apparatus and appliances used in the testing operations of the station.

INTEROCEANIC COMMUNICATION BY WAY OF THE AMERICAN ISTHMUS.

BY LIEUTENANT HENRY H. BARROLL, U.S.N.

(*Concluded from page* 300.)

XXVI.—THE NICARAGUA ROUTE.

THE canal route extends from Greytown, by way of the valley of the San Juan, to Lake Nicaragua, and passing through that lake, thence cutting through the Western divide, and by the valley of the Rio Grande to Brito, where an artificial harbor must be constructed.

The scheme is that of a lock canal having for its summit level Lake Nicaragua. By constructing dams across the San Juan, Deseado, San Francisco and Rio Grande, a system of free navigation is given, all of which is at an elevation of between 106 and 110 ft. above sea-level.

Starting from Greytown, the canal line extends westward through an alluvial soil capable of being dredged. At 10 miles from Greytown is situated Lock No. 1, which has a lift of 31 ft.

Two miles farther westward are situated Locks Nos. 2 and 3, or a double lock, having a combined lift of 75 ft., the highest of these locks opening into the Deseado Basin.

The Deseado Basin is formed among the natural hills by a dam thrown across the Deseado River, by way of which stream the surplus water is carried off.

This basin affords 4.25 miles of free navigation, when a cut of about 2.75 miles through rock is necessary, this being the Eastern divide. This is the deepest cutting on the whole line, and is, on the average, about 135 ft. to the canal bottom, the depth running between 0 and 185 ft.

Once through the Eastern divide, the line enters the San Francisco basin, where 12 miles additional free navigation is encountered to Ochoa, where will be situated the dam across the San Juan River.

This will be about 1,200 ft. along the crest and raise the water 50 ft., while from the lowest part of the foundation to the crest of the dam is about 65 ft.

This dam raises the waters of the San Juan River to 106 ft. above sea-level, the same height as that obtained by the combined lift of locks Nos. 1, 2 and 3. From here to Fort San Carlos, where the San Juan debouches from the lake, is a distance of 64.5 miles. Allowing ¾ in. to the mile as the natural rise of the San Juan in this distance, gives 4 ft. additional elevation at this point.

From Fort San Carlos across the lake, is a distance of 56.5 miles. On the western side of the lake the canal enters a cut of slight depth in earth and rock for nine miles, passing through the Western divide, and issues thence into the Tola Basin, with 5.5 miles free navigation obtained by damming the Rio Grande.

There is from the Tola Basin to the Pacific a perfectly simple way of moving down to the sea-level through the valley of the Rio Grande; but Mr. Menocal has found that by cutting slightly to one side, the line enters a bed of solid rock, and here two locks, in close proximity, will be hewn out of the solid rock, giving a descent of 85 ft., and the canal proceeds in excavation, down the valley of the Rio Grande a distance of two miles, to the last lock—a tidal lock having 30 ft. lift—from which the canal enters the upper part of the harbor of Brito, 1½ miles from the Pacific Ocean.

This is a superior route to that presented by Mr. Menocal before the Paris Conference, in 1879.

The principal question of communication by this route has always been that of passing the Western divide. The San Juan River, forming the only outlet of the lake, leaves it at its southeast extremity, at which point the lake shore nearest approaches the Caribbean Sea. The San Juan Valley, then, shows the lowest level on this side of the lake.

There were eight different proposed routes from the lake to the Pacific.* Commander Lull, by surveys in 1872, eliminated several of these, and limited the field of investigation to those in the vicinity of the Rio del Medio and the Rio Lajas.

It then became apparent that on the Rio Lajas route, provision must be made for the waters of the Guscoyal, Espinal and Rio Grande, as well as eight smaller streams; while only two small ones, the Del Medio and Chocolata, need be provided for on the Medio route.

It was also found that the route by the Del Medio was some 1½ miles shorter, but that the dividing ridge by way of the Medio was 90 ft. higher than that by way of the Rio Lajas.

In 1880 the Secretary of the Navy directed Civil Engineer Menocal to further investigate this locality, in order to determine the practicability of diverting the Rio Grande (a Pacific slope river) into Lake Nicaragua, and thus remove the greatest objection to the Lajas route.

Mr. Menocal met with success in his investigations. Colonel Childs, who had made a study of this route in 1851, had advocated taking the Rio Grande into the canal. Mr. Menocal found that it discharged, at its highest stages, 10,000 cub. ft. of water per second. It was, therefore, out of the question to admit this into the canal.

He proposed a dam across the Rio Grande at a point called El Carmen, about 3,000 ft. from the line of the canal, which would raise the waters of the river sufficiently to allow them to discharge by an artificial channel into a small stream known as the Juan d'Avila, and thence into the Lajas, by which its waters would be emptied into Lake Nicaragua instead of into the Pacific.

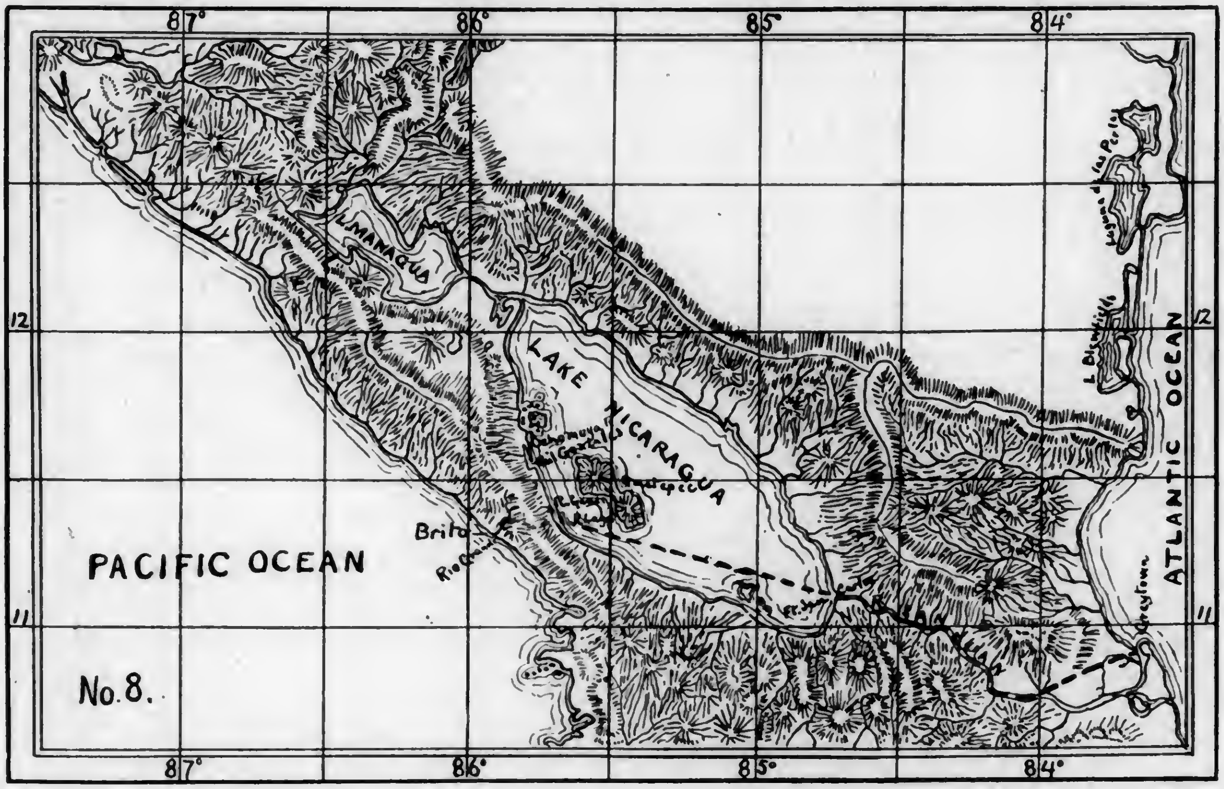
Having established the practicability of diverting the Rio Grande, Mr. Menocal examined the narrow valley occupied by that river below the projected dam, having in view the re-location of the canal-line, so as to utilize the channel, avoiding, as much as possible, the hills on each side, and enlarging the radii of its curves as much as the topography of the country would allow.

This re-location of the line of the western section of the canal made a much more favorable route. By this change, which was completed in 1885, Mr. Menocal esti-

* See pages 203 and 204 in the May number of the JOURNAL.

mates a saving of $16,000,000 on a previously estimated cost of $52,000,000.

For the next two and one half years surveying was constantly going on, to establish absolutely this re-located line, and the canal-route, as now located, undoubtedly occupies the lowest existing depression between North and South America.



The accompanying illustrations show, in No. 8, a general map of the canal and isthmus; in No. 9, a map of the canal line from Lake Nicaragua to the Pacific Ocean, and in No. 10, a general profile of the line arranged in sections.

The total length of the route, from ocean to ocean, is 170 miles, divided as follows:

Canal in excavation, east side........	16 miles.	
Canal in excavation, west side........	11¼ "	
Six locks..............................	¾ "	
Total canal in excavation.........		28 miles.
Basin of Deseado.........	4¼ miles.	
Basin of San Francisco...............	11¼ "	
Basin of Tola......	5½ "	
Total navigation in basin.........		21 "
Free navigation in river San Juan.....	64½ miles.	
Free navigation in Lake Nicaragua...	56½ "	
Total free navigation.............		121 "
Total length from ocean to ocean.....		170 miles.

The dimensions of the canal-prism are as follows: Width at bottom in ordinary depths, 120 ft.; width at water surface in ordinary soils, 180 ft.; depth, 30 ft. In hard rock the prism has a width of only 80 ft. at bottom, and sides battered about 1 to 20.

There are six locks, three each side, which overcome an elevation on the eastern side of 106 ft., and on the western side of 110 ft., this difference being, as already stated, due to using the natural rise of the San Juan River for 64 miles, at ⅛ in. to the mile.

The dimensions of the locks are: Length between mitre-sills, 650 ft.; width (increased from 70 ft. in 1889, and will possibly be increased to 85 ft.), 80 ft.

As to Water Supply, the following is taken from Mr. Menocal's Report, made in 1885, to the Secretary of the Navy:

"Lake Nicaragua has a surface area of 2,600 square miles, and a supplying water-shed of 8,000 square miles. The San Juan River shows a minimum flow of 11,390 cub. ft. per second (984,096,000 cub. ft. daily).

"The estimated water required for one lockage on both sides is 4,046,249 cub. ft.; and estimating 32 double lockages daily, will give 129,479,986 cub. ft. required; leaving an excess, of the lake supply alone, even in the dryest seasons, of 870,520,000 cub. ft.

"To this must also be added the flow of the several tributaries of the San Juan, between the lake and the dam, and also of the San Francisco and its tributaries, which will more than compensate for leakage and evaporation. The latter, however, need not be provided for, it being well known that in these latitudes the condensation during the night fully compensates for the evaporation during the day."

An *Estimate of the Cost* of the canal was made by Mr. Menocal, in 1885, after the present actual location of the line had been determined upon—using the prices for labor, etc., that had been used in computing the cost of the canal as located in 1872–73—finding as follows:

Cost as computed on location of 1885.............	$39,040,134
Add 25 per cent. for contingencies................	9,760,033
Making a total of............................	$48,800,167
Estimated cost as located in 1873, and under same scale of prices	65,722,147
Reduction of cost, due to new location........	$16,921,980

With regard to the prices of labor, etc., used, Mr. Menocal says:

"That the prices to be adopted in estimating the cost of the canal, should be greater than would be required for similar work located in an improved section of this (United States) country, is an admitted fact. A large percentage of this excess will be in the cost of transporting laborers and tools and machinery of every description for the prosecution of the work."

It had also become apparent that the dimensions of the canal, as proposed by Commander Lull's survey in 1873, were not sufficiently large to accommodate the increasing size of vessels; and therefore after the re-location of the line in 1885, computations were made for a canal of larger size.

Notwithstanding the increased size of the locks and the greater depth, the estimated cost, based upon slightly increased prices, was about the same as that of the longer route recommended by Lull, computed under a smaller scale of prices.

The estimate computed from the survey made by Commander Lull, in 1873, amounted to $65,000,000.

The estimated cost of the canal, as now under construction, has not been made public ; the Company seem perfectly willing to submit the amounts of excavation, etc., shown to be necessary, but do not care to commit themselves, as yet, to any assertion as to its probable cost.

In addition to the estimate made in 1885, by Mr. Menocal, the Engineer-in-chief of this Company, a second estimate, made after later and elaborate surveys, did not come seriously far from the first.

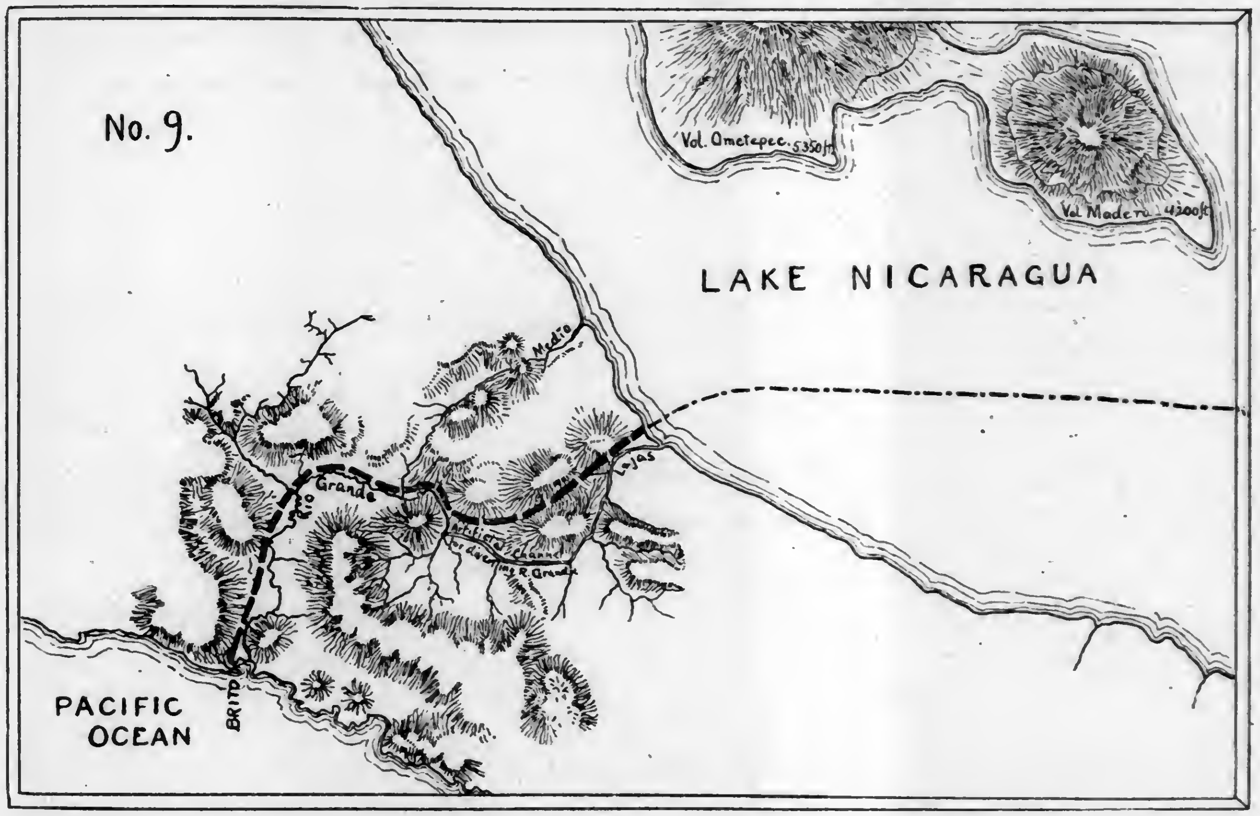
A third estimate was made in the spring of 1889, by a board of five eminent American engineers, none of whom had any connection with the Nicaragua Canal Company.

The report of this board, who made their estimates after some months' work, has not yet been given to the public by the Canal Company, but one can readily believe, from the fact that work is being rapidly pushed in the construction of the canal, that although it may differ somewhat

	Per Cubic Yard.
Earth excavation	$ 0.40
Dredging	0.20
Rock excavation above water	1.50
Rock excavation under water	5.00
Stone pitching (rock furnished)	2.00
Concrete	6.00
Concrete foundation of dams	9.00
Concrete abutments	8.00
Narrow gauge railroad (per mile)	16,000.00
Grubbing and clearing (per acre)	100.00

One can, from these figures, form some idea of its cost. It is safe to assume that the *estimated* cost will not exceed $65,000,000, which has been twice announced as the *probable* cost of this canal.

Where it has been impossible to ascertain by borings the character of the strata to be removed, it has been the rule to allow for excavation of rock ; hence, all subsequent information obtained will tend to reduce rather than increase the estimated cost.



from the first figures, it yet estimates a cost which will permit the remuneration of the Company.

XXVII.—CONSTRUCTION.

The construction of this canal was begun about June 5, 1889, but not until about the middle of October last did actual removal of earth commence.

With regard to the necessary work to be done, the following figures show the amounts of the larger items :

	Cubic Yards.
Excavation of earth below water	23,489,478
Excavation of earth above water	16,440,368
Excavation of rock above water	15,008,347
Excavation of rock under water	575,445
Improvement of harbors (dredging)	14,714,358
Total excavation	70,227,996
Rock fills, for dams and breakwaters	4,845,787
Earth fills, borrowed, or from cuts	5,085,171
Concrete	518,675
Stone pitching	94,813

The scale of prices used in 1885 by Mr. Menocal, was as mentioned below. He states that he has seen no reason to increase them :

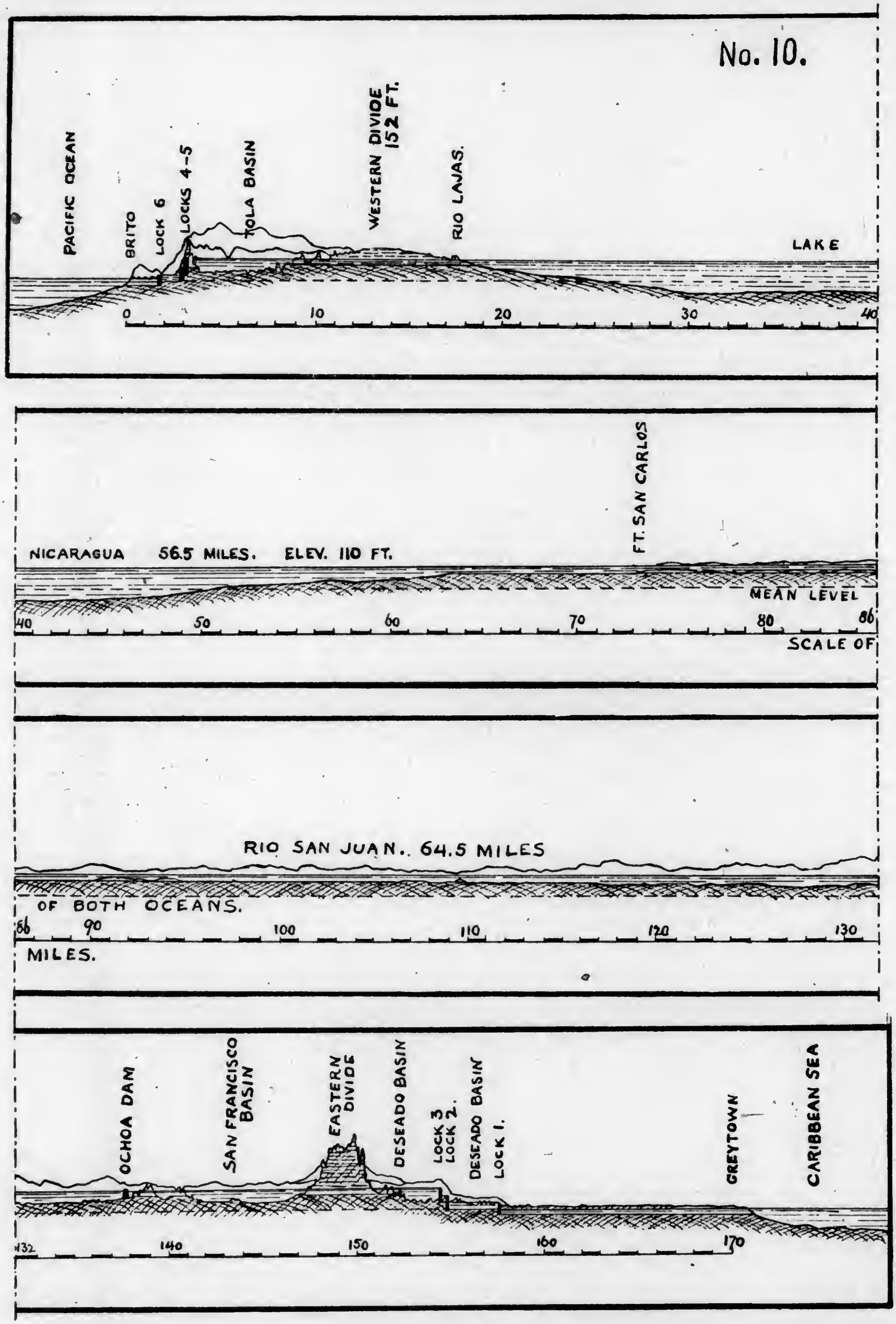
Granting, then, an estimated cost of $65,000,000, and allowing for contingencies 100 per cent., which owing to the nature of the country may well be permitted, we would have, for the total cost of the canal, including administration plant and interest on dormant capital, $130,000,000.

Judging from the record of the Suez Canal, during the past few years, the amount of shipping that will certainly pass through the Nicaragua Canal, will exceed 5,000,000 tons annually. This at a toll of $2 00 per ton—which is about the price now charged for passage through the Suez Canal—would give gross earnings of $10,000,000 ; from which, deducting $1,000,000 for yearly working expenses, there will remain a net receipt of $9 000,000 annually, or in the neighborhood of 7 per cent. interest on the capital invested.

It is plain to be seen that this is not an over-confident view of the future financial condition of this canal.

XXVIII.—SUMMARY.

The following table is a summary showing the relative position occupied by each route with regard to the points of advantage chosen for comparison. It is considered that the points here expressed are arranged in the order of their importance :



PROFILE OF NICARAGUA CANAL.

Points of Advantage.	Nicaragua.	Panama.	Napipi.
1. Excessive rainfall	1	2	2
2. Necessity of tunnel	1	1	3
3. Water supply	1	2	2
4. Elevation to overcome by locks	1	2	3
5. Rivers to control	2	3	1
6. Healthfulness	1	3	2
7. Length of actual canal line	1	3	2
8. Probabilities of gales along the canal line	2	2	1
9. Character of soil to be excavated	1	3	1
10. Calms of Panama Bay	1	2	2
11. Cost of maintenance	1	2½	2
12. Cost of construction, as estimated by American engineers	1	3	2
13. Distance from ocean to ocean	2	1	2
14. Facilities for repairs to vessels	1	2	2
15. Present facilities of transit	2	1	3
16. Established communication with the World' commercial centers	2	1	3
17. Labor obtainable in vicinity of canal line	1	1	3
18. Materials for construction obtainable	2	2	1
19. Supplies and food obtainable	1	2	3
20. Fertility of the soil	1	2	1
21. Proximity to the Gulf ports of the United States	1	2	3
22. Value to the United States in time of war	1	2	3

The opening of a canal across the American Isthmus will greatly benefit those States bordering upon the Mississippi, the Ohio and the Missouri rivers. Their produce and manufactures will find ready transportation to Chile, Peru, San Francisco, and even China and Japan. From New Orleans *via* Nicaragua to Callao, for instance, is only about 2,600 miles.

The importance of this channel-way to the United States in case of a war with any European Power, cannot be overestimated; and should such a contingency arise our Government would have to assume its control.

From present indications the Nicaraguan Canal will be an accomplished fact within the next decade, and we cannot, therefore, afford to delay the launching of a thoroughly efficient force of Naval vessels.

THE BURGENSTOCK CABLE RAILROAD.

THIS road, one of the latest of the Swiss mountain roads, is described in a recent number of the *Zeitschrift* of the German Union of Engineers.

The line, which was built to give access from the steamboat station Kehrsiten, on the Lake of Lucerne, to the summit of the Bürgenstock, has been opened after long difficulties in obtaining the necessary authority for construction, which was granted only after the favorable report of an international commission, and then only on condition that the carriages should work only from each end to the half-way passing-place and back. This restriction has since been waived, so that the carriages can run right through. It was originally intended to work the descending carriage by water-weight, but owing partly to the expense of getting the necessary quantity of water to the summit, and partly to the extra load, and therefore wear and tear of the ropes, this was abandoned; and the line is actually worked by electricity, the dynamos being set in motion by turbines on a stream about 2½ miles distant.

For the first length of 1,312 ft. from the steamboat pier the incline is 32 per cent.; for the rest of the distance the grade is 57.7 per cent. The horizontal length of the line is 2,713 ft., and the equivalent incline length 3,071 ft., the rise in this length being 1,444 ft. With the exception of a passing-place 394 ft. in length, located on a curve of 558 ft. radius, and at the change of grade, the line is single throughout, and of the meter gauge (39.37 in.). The rails are laid with lead-plate bed on angle-bar sleepers 4 in. × 3½ in. in size, firmly secured in cement masonry. The cable is of steel wire, and is 1.18 in. in diameter, composed of 114 wires, and weighing 2.14 lbs. per linear foot. The steel is tested to a load of 89 tons per square inch.

The road is laid with a double plate rack-rail of the Abt pattern, for gearing on the safety brake, by which the speed can be regulated, or the car stopped if necessary. The rack-rail is fixed to the sleepers by stout angle-bars, with a clear intermediate space of 1.1 in. The T-shaped space left is utilized for a device adopted for holding the car to the rails. This consists of a rod fastened to the car frame and having a T-shaped head running in the groove, so that the car cannot be lifted off the rails. The outside wheels are grooved or double-flanged, and the inside wheels (those requiring to pass over the fixed points at the passing-place) are of plain cylindrical form, so that, the outside wheel being guided by the continuous rail, the inner wheel has no difficulty in passing over the rack and the rope grooves at the points.

The car consists of four compartments on an iron frame, the outside dimensions being 19 ft. 8 in. by 5 ft. 3 in. There are two axles 9 ft. 10 in. apart. The general brake arrangements resemble those on the Pilatus Railroad. The car weighs 8,800 lbs., and accommodates 30 persons, the total load being therefore about 13,200 lbs., and the maximum tangential force 6,600 lbs. Adding the weight of the rope and the friction in hauling and winding, the total strain is equal to 13.46 tons, which gives nearly seven as the factor of safety. The vertical cast-iron grooved rollers for the rope are 6¼ in. in diameter, spaced at intervals of 49 ft.; the diameter on curves, where the rollers are set in angular bearings, being 24 in. The average speed is 197 ft. per minute, or 2.236 miles per hour, giving therefore a little over 15 minutes for the entire journey.

The water-power is derived from the Aa, between the villages of Stanz and Buochs, at a point about 1,400 ft. below the level of the summit station. The volume of water is nearly 40,000 gallons per minute, with a fall of 16 ft. 6 in.; and taking the effective work at 75 per cent., the power developed is equivalent to 150 H.P. The turbines make on an average 49.5 revolutions per minute, the vertical shafts being geared by bevel wheels on to a horizontal shaft, making 145 revolutions and working two Thury dynamos at 800 revolutions. The effective power developed is 88.8 per cent., and the current is transmitted by the triplex system to the summit station on the Bürgenstock, where the electrical energy is reconverted into mechanical work. The total weight of copper wire is 3,750 lbs., whereas the weight required for duplex transmission would have been about 10,000 lbs. The electro-motors at the Bürgenstock station make 700 revolutions a minute, giving 170 revolutions to the main driving-shaft and 5 revolutions to the 13-ft. diameter winding rollers. The dynamos are also used for the electric light installation, which comprises 225 glow-lights and one 2,000-candle arc-light. The stations and the turbine-house are also connected by telephone, and the cars in approaching each end of the line cause a bell to sound in the engine-room, while the exact position of each car is reproduced diagramatically in the engine-room by indicators moving in the proportion of 1 to 1,000 of the travel of the rope. When not employed for working the line or the light installation, the electro-motors are used for pumping water to the summit, from a point 1,300 ft. below. The water is raised 6 ft. 6 in. by suction, and then forced through a 2-in. pipe to the summit level, at the rate of about 31 gallons per minute.

FOREST CULTURE IN HANOVER.

(Report by Consular Agent Simon to State Department.)

IN various parts of the United States the question has been raised, by what measures the preservation of forests and the plantation and culture of trees might be most effectually promoted in parts void of timber. In connection with this it might be desirable to learn something about the state of forest management in the province of Hanover. This province, the former Kingdom of Hanover, had rich tracts of forests in former centuries, which, in consequence of civil and other wars at various times, were reduced to desolate wastes and remained so until the first decades of the present century, particularly those ex-

tents between Hamburg and Hanover, which are known by the name of Luneburger Haide (Lunenburg Heath).

Besides those wars, another reason for such devastation is to be attributed to uncongenial management, such as division of common forests, by which they were dispersed and fell into the hands of people with small means, and thus were doomed to neglect and destruction. Those singly situated wooded tracts, for want of screenings, have greatly suffered by the detrimental, inclement winds, which is easily understood, since large forests will defy the violence of storms better than small woods.

Great credit for having made up for past neglect and faults is due to the celebrated Burkhardt, who, being a great authority in this matter, was appointed Director of the forest department in 1850. Part of the Luneburger Haide, as well as other tracts growing more and more desert by the encroachments of sand, have been wooded with great pains and trouble at his instigation. To prevent the increase of sandy deserts those tracts were at first planted with fir-trees. These could, in some parts, after a number of years, be cleared and substituted by beach and other trees. How much the forests have been enlarged in this manner will appear by the following statement: The wooded surface amounted in the year 1850 to 1,217,625 acres; 1885, to 1,551,900 acres. By such plantation of trees river-bank and sea-shore tracts have been solidified. In consequence of the notorious fact that forests have a great influence on the climate and the attraction of moisture, meteorological stations have been established. Forests serve, moreover, as bulwarks against violent winds, and equalize to some extent the extreme differences of temperature. The absorption of water by trees and undergrowth after heavy rains or melting of snow is very considerable, particularly in such tracts where the forest soil predominates; so that well-wooded hills and mountains are the best protection against destructive inundations. In order to promote the establishment of forests in every respect, the Government has granted large sums for the purchase of landed property unfit for cultivation to be turned into forest tracts. The Government is now keenly intent to unite again those formerly scattered wooded parts into one single tract. In the same way the Provincial Government and Klosterkammer (Administration of cloister funds) proceed by purchasing extensive stretches of soil. The Klosterkammer administers the large funds of the secularized cloisters of the former Kingdom of Hanover, now used for the support of universities, schools, and churches in this province.

Municipalities, communities, and even private individuals who are inclined to establish forest grounds and manage them rationally will receive loans at 2 per cent. and even cheaper from the Provincial Government, to be reimbursed yearly by small installments. Also, single subsidies are granted for once for the turning of large wastes into forest grounds. For the latter purpose the provincial government resorted to a new and original method, by using vagabonds, tramps and prisoners not of a dangerous character for forest culture, and, indeed, according to experience, with great advantage both with regard to the workers and forest culture. In this manner about 9,000 acres were planted with trees by those troublesome classes within the years 1876 to 1888. Moreover, communities as well as private individuals have turned about 14,000 acres into forest grounds within the same period by means of subsidies afforded by the Provincial Government. Besides, the matter of forest culture is encouraged and promoted on the part of the Government, as well as the provincial authorities, by the establishment of nurseries, where plants and young trees are to be had at very moderate prices.

By a legal preservation of forests in the vicinities of towns pleasant walks are created for the pleasure and health of the inhabitants, without regard to the material profit of those places. At a short distance from the old city of Hanover, for instance, was the so-called Eilenreide, a forest of about 1,500 acres, which the city now partly encircles. This forest has essentially contributed to the reputation of Hanover, with regard to sanitary condition, to the extent of its being now, according to statistics, one of the healthiest cities in Germany. Several smaller towns which own extensive forest grounds and manage them in a rational way, clear by the net yielding of those woods the whole of their municipal expenses; as, for instance, the town of Munder, situated at the foot of the Deister Mountains. The town of Goslar derives an income of $25,000 to $30,000 from an extent of 7,500 acres of forest grounds. Every traveler on an excursion to Goslar and other parts of the Hartz Mountains will have admired the fine, practical forest roads which facilitate the transport of wood. It has been estimated that, by the higher prices which the town receives at the sale of the wood on account of the easier transport, the capital invested in making these roads and keeping them in good condition yields 20 per cent. yearly.

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C.E.

(*Continued from page 257.*)

CHAPTER XXVI.

HOWE TRUSS BRIDGES.

With this chapter is given the design for a Howe truss through bridge of 54 ft. span. In Plate 112 will be found the general elevation and plan, with strain sheet; in Plate

No. 46. Bill of Material for Howe Truss Bridge, 54 Ft. Span. Plates 112, 113, 114 and 115.

Timber.

No. of Pieces.	Description.	Size.	Length.	Material.
2	Top Chord..........	6 in. × 12 in.	15 ft. 6¾ in.	Yellow Pine.
2	" "	6 in. × 12 in.	24 ft. 6¼ in.	" "
1	" "	8 in. × 12 in.	40 ft. 1 in.	" "
2	Bottom Chord... ..	6 in. × 14 in.	16 ft. 6 in.	" "
2	" "	6 in. × 14 in.	43 ft. 6 in.	" "
1	" "	8 in. × 14 in.	25 ft. 0 in.	" "
1	" "	8 in. × 14 in.	35 ft. 0 in.	" "
8	Braces	12 in. × 9 in.	25 ft. 0 in.	" "
8	"	10 in. × 8 in.	25 ft. 0 in.	" "
8	"	9 in. × 7 in.	25 ft. 0 in.	" "
8	Counters...........	9 in. × 7 in.	25 ft. 0 in.	" "
4	End-post braces....	9 in. × 7 in.	14 ft. 0 in.	" "
6	Top laterals.	8 in. × 8 in.	18 ft. $2\frac{1}{16}$ in.	" "
8	Bottom laterals.....	8 in. × 8 in.	17 ft. 10 in.	" "
2	" "	8 in. × 8 in.	16 ft. $4\frac{1}{16}$ in.	" "
8	Bolsters............	6 in. × 10 in.	9 ft. 0 in.	" "
4	"	8 in. × 10 in.	9 ft. 0 in.	" "
8	Bridge-seats........	6 in. × 10 in.	4 ft. 6 in.	" "
4	" "	8 in. × 10 in.	4 ft. 6 in.	" "
4	Sills...............	12 in. × 12 in.	18 ft. 0 in.	Spruce or Pine.
22	Floor-beams.........	9 in. × 16 in.	17 ft. 10 in.	" " "
6	Stringers...........	6 in. × 12 in.	60 ft. 0 in.	" " "
52	Ties................	8 in. × 8 in.	12 ft. 0 in.	Oak.
2	Guard-rails.........	6 in. × 6 in.	60 ft. 0 in.	Spruce or Pine.
4	Foot-planks	2 in. × 6 in.	60 ft. 0 in.	" " "
8	Keying blocks......	2 in. × 8 in.	2 ft. 0 in.	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2⅝ in.	26 ft. 10 in.	12	Brace-bolts.	⅞ in.	2 ft. 0½ in.
8	"	2 in.	26 ft. 10 in.	12	Bolster-b'lts	1¼ in.	2 ft. 2 in.
4	"	1⅝ in.	26 ft. 10 in.	12	" "	1¼ in.	3 ft. 0 in.
2	Top laterals	1½ in.	18 ft. 6 in.	44	Fl. beam b'ts	1¼ in.	3 ft. 6 in.
2	" "	1⅜ in.	18 ft. 6 in.	44	String'rb'lts	¾ in.	2 ft. 6 in.
4	Bottom lat.	1¾ in.	18 ft. 6 in.	104	Tie-bolts.	¾ in.	1 ft. 10 in.
2	" "	1½ in.	16 ft. 6 in.	34	Guard-bolts.	¾ in.	1 ft. 4 in.
124	Chord-bolts.	¾ in.	2 ft. 0½ in.	40	Spikes.	½ in.	....

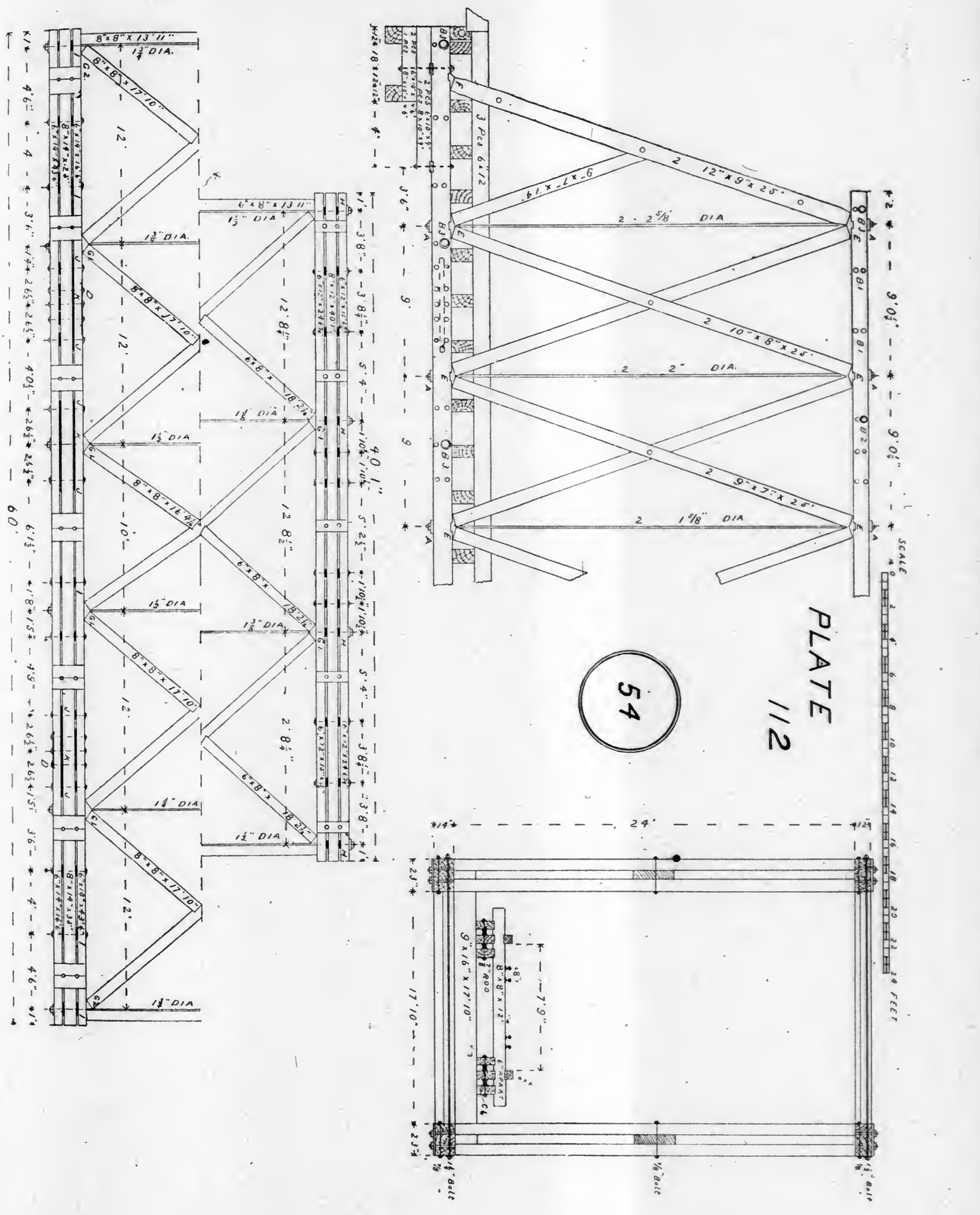


PLATE
112
54
SCALE
FEET
3 Pcs 6"x12"
2 10"x8"x25'
2 9"x7"x25'
2 12"x9"x25'
2 2" DIA.
2 1 5/8" DIA
2 - 2 5/8" DIA
60'
40' 1"
24'
17' 10"
7' 9"

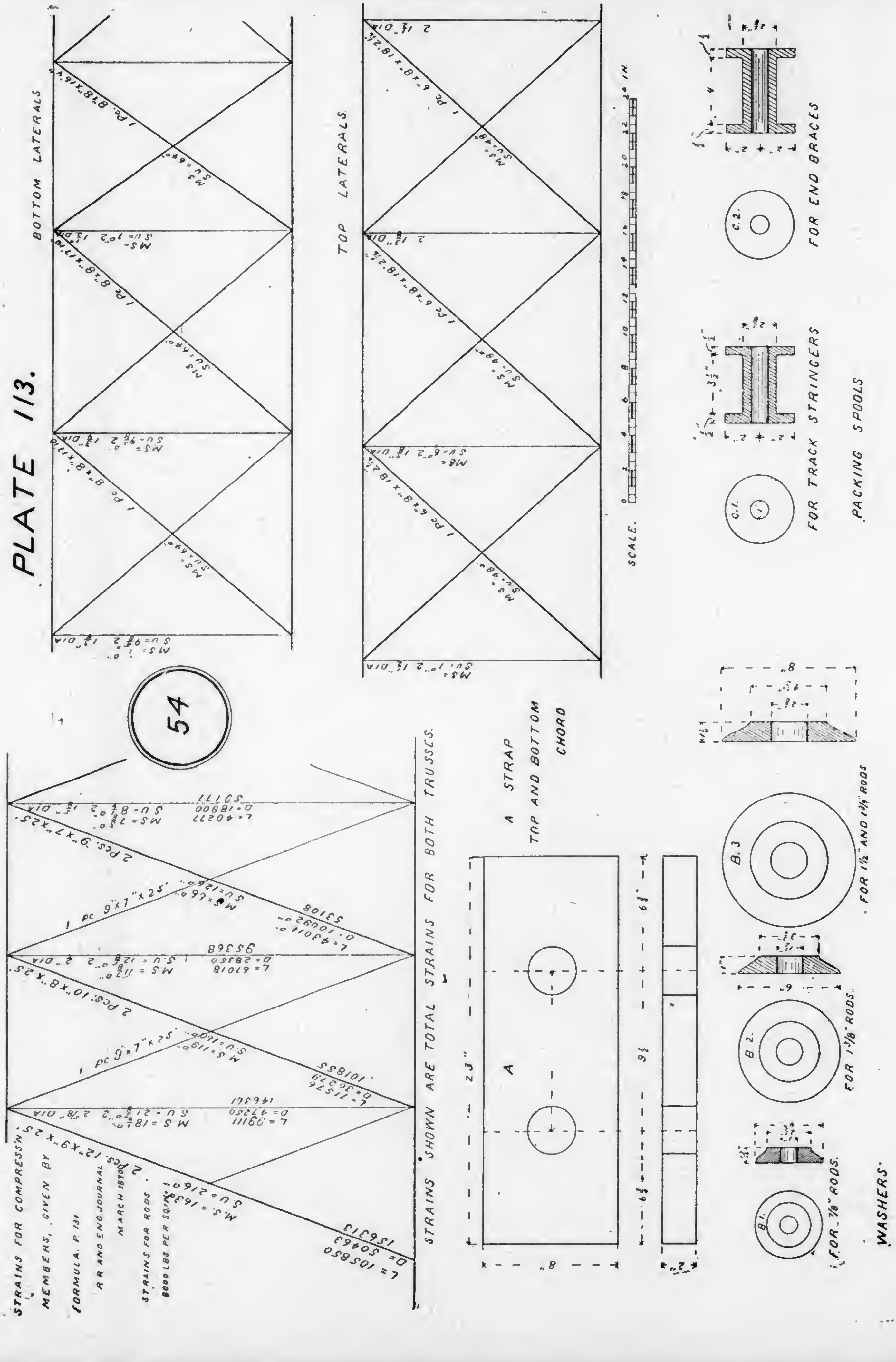


PLATE 113.
54
BOTTOM LATERALS
TOP LATERALS
SCALE.
FOR END BRACES
FOR TRACK STRINGERS
PACKING SPOOLS
A STRAP
TOP AND BOTTOM
CHORD
STRAINS SHOWN ARE TOTAL STRAINS FOR BOTH TRUSSES.
STRAINS FOR COMPRESS'N MEMBERS, GIVEN BY FORMULA. P. 131
R R AND ENG JOURNAL MARCH 1890
STRAINS FOR RODS 8000 LBS PER SQ. IN.
FOR 1½" AND 1¾" RODS
FOR 1⅜" RODS.
FOR ⅞" RODS.
WASHERS.

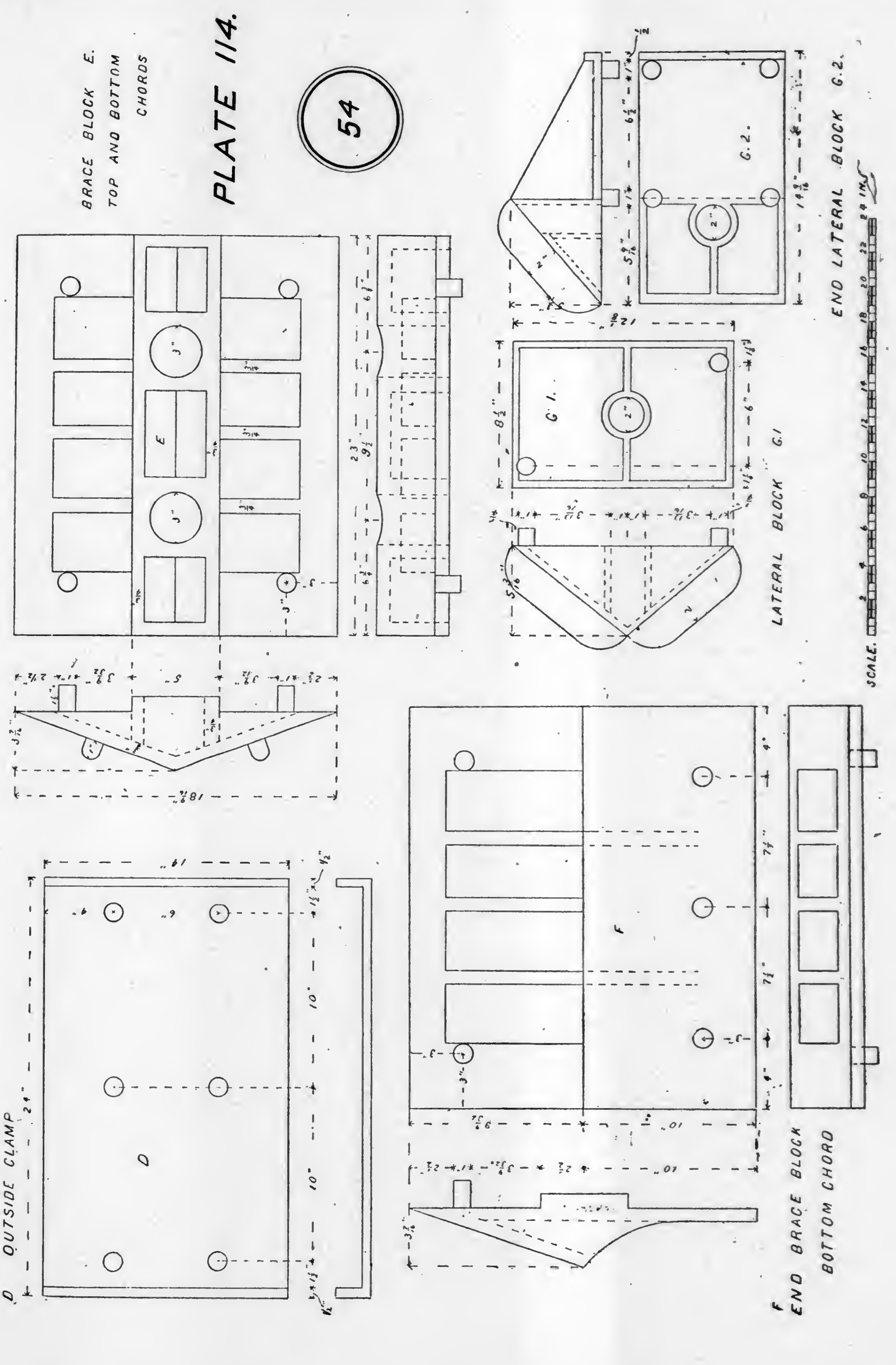


PLATE 114.
54
BRACE BLOCK E.
TOP AND BOTTOM
CHORDS
LATERAL BLOCK G.1
END LATERAL BLOCK G.2.
D OUTSIDE CLAMP
F END BRACE BLOCK
BOTTOM CHORD
SCALE.

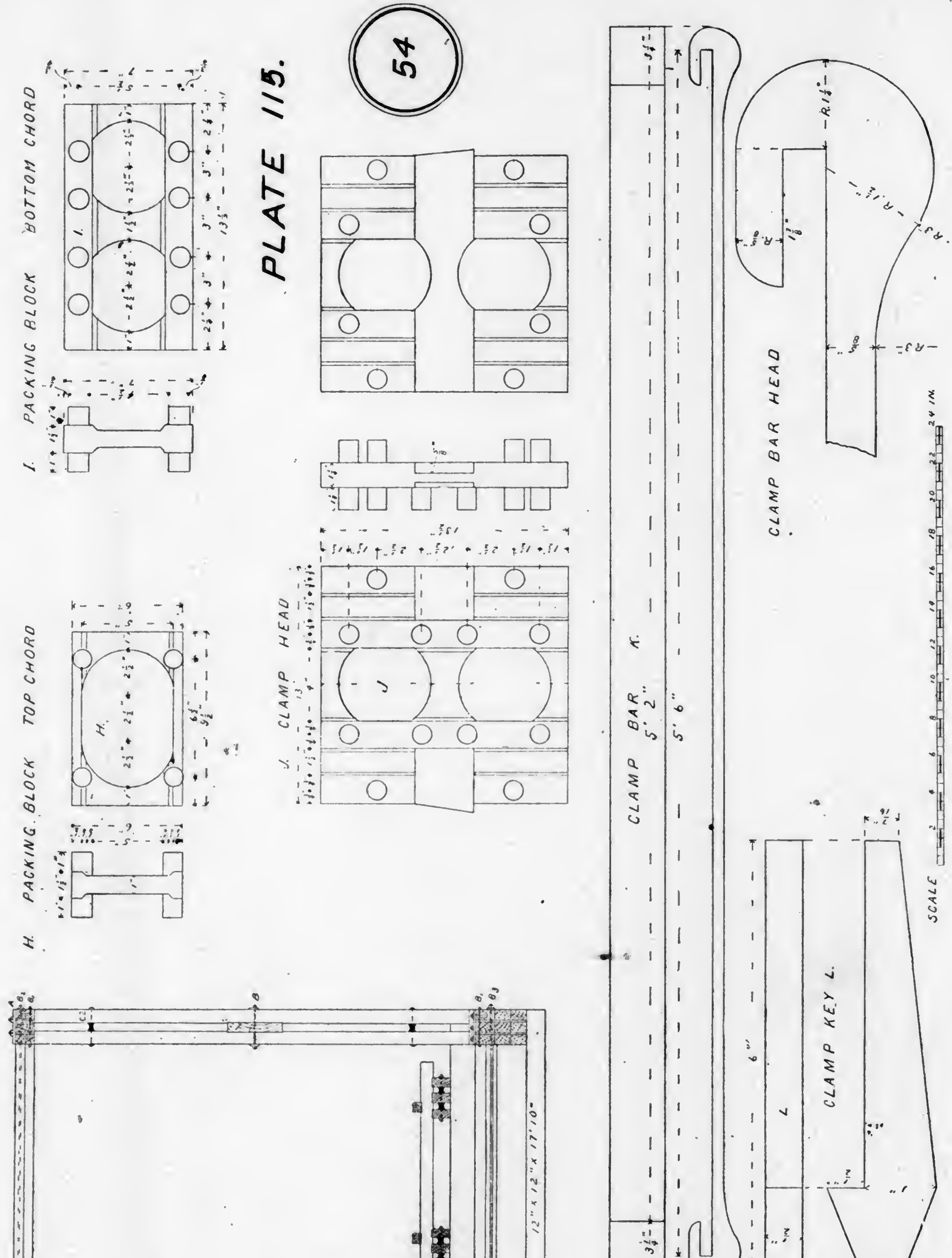


PLATE 115.
54
I. PACKING BLOCK BOTTOM CHORD
H. PACKING BLOCK TOP CHORD
J. CLAMP HEAD
CLAMP BAR K.
5' 2"
5' 6"
CLAMP BAR HEAD
CLAMP KEY L.
SCALE
12" x 12" x 17' 10"

Castings.

Pieces: 24 straps *A*; 636 of *B1*; 136 of *B2*; 36 of *C1*; 8 of *C2*; 2 of *D*; 24 of *E*; 4 of *F*; 12 of *G1*; 8 of *G2*; 48 of *H*; 72 of *I*; 8 of *J*; 4 of *K*; 8 of *L*.

113 an end view and part of the details, and in Plates 114 and 115 the remaining details.

The bill of materials is also given, and, it is believed, the plates and bill will show the design and construction of the bridge clearly enough, without further description.

(TO BE CONTINUED.)

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

X. BATTERY MATERIALS.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page* 313.)

To those who do not understand the details of railroading at the present day, it may perhaps be somewhat of an astonishing statement to say that the train movement on any busy railroad at present would be an impossibility without the telegraph; and this does not mean that the operation of a railroad requires that the telegraph shall be used for the officers to communicate with each other on matters of policy, or about the purchase of supplies, or other general questions which are constantly coming up, important as these may be for the general operation of a railroad, but it does mean that the actual movement of the trains, the getting of the traffic over the road, the prevention of delays, collisions, and accidents of all kinds, and the meeting of the dozen and one emergencies, which are constantly arising in train movement, are all regulated by means of the telegraph, and that without the telegraph complicated train movement would be impossible, at least without such a multiplication of tracks as would double or treble the investment of most railroads.

In view of the great reliance placed on the telegraph in modern railroad operation, the question of materials used in the battery to furnish the electricity with which to operate the lines assumes new importance, and the object of this article is to give the experience of the Pennsylvania Railroad in *Battery Material*. The questions of the telegraph lines, of the construction used, of size of wire, of distance of poles from each other, of overhead and underground lines will not be discussed in this article. Possibly in some future article of this series these questions may be treated at length, but at present only the materials used in generating the electricity will be discussed.

The history of the battery as applied to telegraph work and the development of the present simple form, which, so far as our knowledge goes, is almost universally used for this purpose, would be very interesting reading, but this likewise is foreign to our purpose. Suffice it to say that, so far as we know, what is known as the "Gravity Battery," the elements of which consist of one pole of metallic zinc, one pole of metallic copper, the latter being surrounded by a concentrated solution of sulphate of copper, and the former with a more or less dilute solution of sulphate of zinc, is now almost everywhere in use for telegraphic purposes. In this battery, as is well known, the containing cell is usually made of glass, and the ordinary size in most common use holds about one gallon. It should be placed in a dry, moderately warm room, and is best if insulated on a porcelain insulator. It is a great mistake, made many times, to locate the battery in a damp, cold cellar, and to set the cells forming the battery on any damp support. Being itself a part of the line, the battery should be as well insulated as the wire, and experience shows that the leakages and difficulties in service disappear more and more the better the insulation.

It is well known that in an ordinary gravity battery the copper pole occupies the bottom of the cell, being connected with the zinc of the next cell by a copper wire, usually insulated with rubber or gutta percha. The copper pole is surrounded by crystallized sulphate of copper, the usual custom being to fill the battery cell perhaps one-quarter full with the dry material. Soft water as free as possible from mineral matter—rain water is best—should be used to fill the battery cell up to within an inch or an inch and a half of the top. The zinc pole of the cell suspended from the cover, or by a bar across the top of the cell, is then put into the water, and it is best to add to the clear water solution a little sulphate of zinc solution, taken from an old battery cell. Many prefer to connect the two poles of a newly charged cell together for a few hours, thus doing what is technically known as "short circuiting" the cell to start the action. This is not very good practice, but it is quite frequently done. Quite serious difficulties would be experienced with this method, if a large number of cells in any battery that was being worked were renewed at one time, since the resistance of pure water is so much higher than the resistance of water containing salts in solution. The best method of starting a battery cell is to put the copper pole in the bottom of the cell and surround it with the crystallized sulphate of copper, as above described. Then fill about one-third full of water, or a little above the crystallized sulphate of copper, and allow it to stand over night. Then fill in above this blue solution to within 1 in. or $1\frac{1}{2}$ in. from the top of the cell with a liquid made of one part sulphate of zinc solution, taken out of an old battery cell, and two parts clean water. In introducing this solution into the new battery cell, it is best to put a thin board, a little smaller in diameter than the inside of the cell, on top of the blue solution, and then pour the sulphate of zinc solution on to this board. In this way there is very little disturbance of the blue solution, it being well known that it is essential in the action of the battery that the blue and white solutions should not mix. Suspend now the zinc pole in the white solution as above described, and the cell is ready for use. It is not necessary, of course, to say that the copper pole of one cell is connected with the zinc pole of the next, and so on to the end.

In the practical operation of the battery as above described, it is found that the liquid evaporates badly, especially during dry and warm weather, and many devices have been made use of to overcome this difficulty. Some people use a layer of paraffine oil, possibly $\frac{1}{8}$ in. thick, on top of the battery liquid. This was formerly the custom on the Pennsylvania Railroad, and the only serious objection to it that we are familiar with is that it is somewhat dirty. Later practice has been to have a wooden cover made for the purpose, which fits fairly tight to the battery cell, which cover likewise serves as a support for the zinc pole, and has in it a two-inch hole for the introduction of the sulphate of copper from time to time, and to enable the sulphate of zinc solution to be drawn out if desired, which hole is covered with a small metallic slide cover. This keeps the battery cleaner and is in every way the most efficient scheme which has been tried, and we believe the practice is becoming universal throughout the system.

The chemical action of the gravity cell is probably quite complicated, and we are not sure that all the reactions which take place have ever been fully investigated or worked out. If the battery works as we would expect it to work theoretically, the result of the action would be as

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the Journal for December, is on the Work of the Chemist on a Railroad; No. II, in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils; No. VIII, in the July number, on the method of purchasing oils; No. IX, also in the July number, on Hot Box and Lubricating Greases. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these Contributions to Practical Railroad Information of special value in indicating the true character of the materials they must use and buy.

follows : Metallic copper from the sulphate of copper is deposited on the copper pole in the bottom of the cell. This releases the sulphuric acid with which the copper was combined in the sulphate of copper. This sulphuric acid ultimately combines with the zinc, forming sulphate of zinc, which goes into solution and stays in the top of the cell around the zinc pole. We say theoretically this is the action of the battery, namely, a transfer of sulphuric acid from its combination with copper in sulphate of copper, to the metallic zinc, and forming sulphate of zinc ; but in addition to this, there is always a coating of oxide and basic sulphate of zinc formed on the zinc pole. This deposit is usually said to be the result of "local action," but whether this explains the phenomenon or not we are unable to say, and it is hardly essential to our purpose to go into this part of the subject. It will be observed that as the action of the battery continues, there will be an increase in the amount of metallic copper, a diminution in the amount of sulphate of copper, a diminution in the amount of metallic zinc, and an increase in the amount of sulphate of zinc. The care of the battery, therefore, requires the addition of two things, and the removing of two things, namely, sulphate of copper and new zinc must be added, and the metallic copper and the sulphate of zinc must be removed. In practice it is usually customary to add the sulphate of copper from time to time through the hole in the cover, and to draw out the sulphate of zinc, as the solution becomes too concentrated, replacing it with pure water from time to time. Whenever it is necessary to furnish new zinc or to remove the metallic copper, usually the cell is cleaned out entirely and a fresh start made.

It is very easy to see when more sulphate of copper is needed, and it not infrequently happens, if a battery is neglected, that a difficulty arises from the exhaustion of sulphate of copper. The most common difficulty, however, is in allowing the sulphate of zinc to become too concentrated.

When this occurs a thin layer of crystallized sulphate of zinc frequently forms on the inside of the cell at the top of the solution, which layer gradually extends to the top of the cell, and the liquid creeps up between this layer and the glass of the cell, until it runs over the top. This creeping up of the liquid makes very dirty cells and interferes seriously with the insulation, since as soon as the liquid gets to the top it runs down on the outside and interferes with the insulation of the cell. In good battery practice the sulphate of zinc solution should never be allowed to become as concentrated as this. Most of the books of instruction to those having the care of batteries contain directions in regard to allowing the sulphate of zinc solution to become too concentrated, and recommend to employ a hydrometer to take the density of the solution, and never allow it to reach the danger line of concentration.

With good materials and with proper care the gravity cell gives very good results, although its electro-motive force is, as is well known, rather low, and the number of cells required consequently much greater than could be desired. We do not, however, know of anything better at the present time than the ordinary gravity cell, and when, as is the ordinary custom we believe almost everywhere, the lines are worked on closed circuit, the behavior of this cell, if it gets the care it ought to have, is fairly satisfactory.

If the action of the battery was simply confined to that which has been described above, namely, to the deposition of the metallic copper and the formation of sulphate of zinc, it is unquestioned that the purer the sulphate of copper and the purer the metallic zinc, the better the action of the battery would be. We have expressed a doubt as to whether even the normal action of the battery was wholly explained by this simple reaction, and still further expressed a doubt as to whether the impurities which are necessary concomitants of the zinc and sulphate of copper used, or "local action" are complete explanations of all the additional reactions which may take place in the battery. Every effort has been made for a number of years past on the Pennsylvania Railroad to secure the purest possible materials for battery use, but this effort has not succeeded in preventing the deposition of scale on the zinc pole, and, as above described, it is possible that the impurities in the zinc, or "local action" may be the cause of this difficulty, and that no commercial zinc can be obtained which will be free from it, or, in other words, although the purest commercial materials are used, there is still enough impurity left to set up "local action," with the result of forming a scale on the zinc pole, as above described. We are hardly able to set this point at rest. One thing is certain, however, that impurities in the zinc are not desirable, and certain impurities are exceedingly objectionable, as will be described below. In order to reduce the impurities to the least possible amount, zinc for battery use has for some time been bought on the Pennsylvania Railroad, in accordance with the following specifications :

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Zinc.

Ordinary Slab Zinc or Spelter, and Rolled or Cast Rod Zinc used for battery purposes, will be bought under this specification. It does not apply to Sheet Zinc nor to Galvanized Iron.

The material desired is Metallic Zinc, as free as possible from every other substance.

Shipments will not be accepted which show on analysis in addition to the Zinc more than one-fourth of 1 per cent. of Lead, or more than one-tenth of 1 per cent. of any other substance.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of the General Superintendent Motive Power, Altoona, Pa., April 2, 1887.

When a shipment of zinc is received, it usually comes in the form of slabs about an inch thick, 7 or 8 in. wide, and 2 ft. long. These slabs are known in the market as spelter.

A sample from the shipment is sent to the Laboratory and examined. It will be observed that more than 0.25 per cent. of lead is excluded, and more than 0.10 per cent. of any other substance. The ordinary impurities in zinc that we search for are lead and iron, these being the most common ones. The zinc may likewise contain small amounts of arsenic, tin, cadmium and copper. We have also always suspected the presence of carbon, but have never positively demonstrated whether it was there or not. American zincs have very small amounts of arsenic ; most of the foreign zincs have very perceptible amounts of it. We have never had any very serious difficulties due to any impurities except iron and lead, and so far as our examinations have gone, the tin, cadmium and copper are very small in amount. The worst impurity is lead, and it is very evident why this should be so. As has already been described, the action of the battery consists in the transfer of the sulphuric acid combined with the sulphate of copper to the zinc. If now the zinc pole contains 1 or 2 per cent. of lead, the sulphuric acid forms with this lead sulphate of lead, which being insoluble in the solution, remains on the zinc pole, and sooner or later the zinc pole becomes so coated with a compact, dense layer of sulphate of lead, that the action of the battery almost entirely ceases. We have examined a number of times zincs which have been complained of where this was entirely the explanation of the difficulty. The zinc was not half worn out, simply because the sulphate of lead formed prevented further action, and, of course, without action no electricity results. We would be glad if we could get zinc entirely free from lead, and at one time succeeded pretty well on this point ; but zinc free from lead is so much more expensive than that containing such amounts as our specifications allow, that we deemed it not advisable to buy the more expensive material. We have very little if any difficulty arising from this cause if the zinc fills the requirements of our specifications.

The iron is limited, as is seen, to 0.10 per cent. Unquestionably the iron is the most fertile cause of so-called "local action"—that is to say, the iron and the zinc in contiguous parts form a battery by themselves, resulting in the decomposition of the metal, but affording no useful current, and it is possible, as above stated, that the scale which forms on the zinc pole may be fully accounted for by the local action due to the impurity. That the iron has an important influence in this matter is clear, we think, from this fact. The more iron there is present in the zinc, the more scale there is formed on the zinc pole, and likewise the more this scale breaks up and falls off from the zinc. Indeed, one of the objections made to our specifications, is that they give a zinc which is too pure, and

that the scale on the zinc pole does not disintegrate and break up owing to the lack of impurity. Many practical battery men believe that the white scale which forms on the zinc pole should be detached from time to time, or else the battery will cease to act. Our experience has not indicated this to be true, unless this white scale on the zinc pole is largely sulphate of lead, in which case it is true. We prefer to meet the difficulty of the scale adhering to the zinc pole by the addition of a few drops of sulphuric acid to the cell from time to time, or perhaps better still by a modification of the zinc. We are making experiments upon this point at present, which experiments are hardly sufficiently advanced to warrant publication. So far as our experience goes, however, very little difficulty will be experienced by the white scale on the zinc pole, provided the scale is not due to lead, and at present the best remedy is to add a few drops of oil of vitriol to the battery cell from time to time.

In casting battery zincs out of the slab spelter the metal should never be melted in an iron vessel, since it is well known that the zinc alloys with iron rapidly. In our experience we have found the amount of iron doubled in the finished zinc from what it was in the zinc with which we started, when we melted in an iron vessel. At present the melting is done in a large flat graphite crucible, made for the purpose.

We determine the amount of iron present in the zinc by dissolving the zinc in dilute sulphuric acid in a flask, using a rubber tube valve, to prevent the air getting at the liquid, and then titrate direct with permanganate of potash in the ordinary way. For the lead the metal is dissolved in nitric acid, and the lead precipitated in ammoniacal solution with phosphate of soda, according to Abel and Field's method, the lead being subsequently weighed as sulphate.

The sulphate of copper used in the batteries is purchased on the following specifications :

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Sulphate of Copper or Blue Vitriol.

The material desired under this specification is the Normal Crystallized Sulphate of Copper, as free as possible from all other substances. From this date this material for the use of the Pennsylvania Railroad Company must meet the following requirements :

I. It must not contain more than ½ of 1 per cent. of Crystallized Sulphate of Iron.

II. It must not contain more than ½ of 1 per cent. of other impurities.

III. Each shipment must be crushed so as to go through a sieve 1½ in. mesh, and must contain nothing that will go through a sieve of $\frac{3}{16}$ in. mesh.

Shipments which fail to meet above requirements will be rejected.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of the General Superintendent Motive Power, Altoona, Pa., January 25, 1887.

It is well known by those who are well informed on the subject that the ordinary impurity of the sulphate of copper is almost entirely sulphate of iron, and sand or dirt. There may likewise be other substances present, especially other soluble sulphates, which crystallize along with the sulphate of copper. Since these other substances, to quite an extent, at least, would be direct falsifications, and are so easily detected, we think there is very little attempt among the manufacturers to give a material that is not what it should be. At least, so far as our experience goes, we have found very little to contend against in this material except the sulphate of iron. This at times might become quite a serious source of difficulty, and accordingly every shipment is examined for this impurity, the search for other impurities being confined to occasional more thorough analyses. With proper care on the part of the manufacturers, the specifications in regard to sulphate of copper are not difficult to fill. Much of the blue vitriol in the market runs as high as 0.75 to 1.00 per cent., and indeed we have seen it as high as 1.50 per cent. sulphate of iron. The object of excluding this material is to render the action of the battery as simple as possible, as well as to prevent the purchase of sulphate of iron, which is an exceedingly cheap substance, at the price of sulphate of copper. The crushing of the crystals is to facilitate the introduction of the material in through the hole in the cover of the battery cell, as above described. The specifications for blue vitriol have worked with very little difficulty for a number of years, and it has been a long time since we were compelled to reject material on these specifications. We determine the sulphate of iron by dissolving a weighed amount of blue vitriol as we receive it in water, heating nearly to boiling, and adding a few drops of nitric acid to be sure that the iron is oxidized to the form of the sesqui salt. We then precipitate hot with ammonia, filter and treat the oxide of iron obtained on the filter with dilute sulphuric acid, and then reduce this with zinc and titrate with permanganate of potash. The figure obtained, representing the iron, is then calculated to the crystallized sulphate.

The gravity cell as above described is growing in use continually, but a small number of Leclanche cells are used, especially on call and signal bells, and where intermittent work on open circuit is required. For this work even, in many places, the ordinary gravity cell is constantly taking the place of the Leclanche cell. Also some of the various forms of dry battery which are coming forward at the present time are being experimented with for this work, and especially is the dry battery being used where it is necessary to transport the battery, as on the call bells in cars. The Leclanche cell, as is well known, is a carbon-zinc cell—that is, one pole is carbon and the other zinc. There are various modifications, but in general the carbon pole is surrounded with crushed coke and black oxide of manganese, and contained in a porous cell. This cell is placed in a somewhat larger glass cell, which glass cell contains the zinc pole, the space between being filled with a solution of sal ammoniac or chloride of ammonium. Of late years the porous cell has been removed ; what was originally the carbon pole being made of crushed carbon and binoxide of manganese pressed into a solid mass with some binding material. The pole thus formed is then placed in the chloride of ammonium solution, alongside of the zinc, but separated from it. The Leclanche batteries are mostly bought with the carbon pole already prepared, and consequently our specifications have to do with the zinc and sal ammoniac. The same zinc is used to make the Leclanche poles that is used for the gravity cells, the only difference being that they are cast in rods, about ⅜ in. to ½ in. in diameter. The sal ammoniac used in these batteries is purchased on the following specifications :

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Sal Ammoniac.

The material desired under this specification is granulated Chloride of Ammonium [NH_4Cl] as free as possible from every other substance. The fibrous material is unobjectionable, provided it is crushed finely enough.

Shipments will not be accepted which :

I. Are not in the granulated form, or in case the crushed fibrous material is sent, if the pieces are larger than a wheat kernel.

II. Contain less than 65.15 per cent. of Chlorine.

III. Contain less than 31.20 per cent. of Ammonia [NH_3]

THEODORE N. ELY,
General Superintendent Motive Power.

Office of the General Superintendent Motive Power, Altoona, Pa., October 31, 1887.

In our experience, the difficulties with sal ammoniac are largely due to dirt, to oxide of iron, and sometimes to the presence of sulphates, especially sulphates of the alkalies. We accordingly determine the amounts of chlorine and ammonia, the amounts represented by the figures being sufficiently below the theoretically pure material to allow for the presence of about 1.50 to 2.00 per cent. of moisture, and a trace of other impurities. These specifications work very smoothly, except that occasionally a new party, who is not accustomed to furnish material as good as our specifications require, furnishes material which fails to meet requirements.

We determine the chlorine by taking a weighed amount

of the sal ammoniac, dissolving in water, and then triturating with a solution of nitrate of silver of known strength, using chromate of potash as an indicator to determine the end reaction. The ammonia is determined by taking a weighed amount of the material, dissolving in water in a flask, then treating with an excess of caustic potash and boiling. The ammonia is set free and is caught in a standard sulphuric acid solution. A known amount of this solution is taken, and the excess that is not satisfied with the ammonia is determined, the difference giving the ammonia.

With the development of electric light plants along the line, both those under the control of the Company and the local companies furnishing light to the towns, there is quite a disposition to operate telegraph lines with electricity obtained from dynamos. This is believed to work very satisfactorily, and where the electricity can be obtained in this way, it results in great economy. If it is necessary to put in a special plant for the purpose, it would be quite otherwise, since the amount of electricity required to operate telegraph lines is so small. It may be not generally known that the total current required to operate 30 or 40 telegraph lines side by side is not greater in amount than would be required to run two incandescent lamps. The great difficulty with dynamo electricity for telegraph service is that usually in the telegraph service the lines are so long, and the number of instruments are so great, that very high electro-motive force is required, with a very small amount of current. On the other hand, most of the dynamos used for incandescent lighting, at least, are built with moderately low electro-motive force, and with very high capacity. Where the electro-motive force is sufficiently high to overcome the resistance of the telegraph circuit, it is, as said above, very desirable to use this source of electricity, provided it can be obtained from the lighting service. Where the resistance is too great, or where a special plant has to be put in for the purpose, we are inclined to think the batteries will have to be used for a period of time, at least.

In the next article a discussion of paints will be begun.

(TO BE CONTINUED.)

AN INDIAN ENGINEER'S PREDICAMENT.

THE striking illustration given on this page—which is reduced from the London *Graphic*—shows the unexpected and somewhat startling predicament of an engineer making a little trip of inspection on an East Indian railroad. He has come suddenly upon a little family party which has camped out, without leave, upon the right-of-way, apparently in entire disregard of the claims of the company; he has no automatic brake, and cannot reverse, for his motive power has deserted him.

The predicament, as shown in the picture, is bad enough, but it is on record that the result was *not* a vacancy in the maintenance-of-way department, as might have been expected. Either the family party was conscious of the fact that its members were trespassers, they were frightened at the car, or else they were not hungry, for before the hand-car reached them they rose and quietly walked off into the jungle—very much to the relief of their unwilling visitor, who survived to make the sketch from which this drawing was afterward elaborated.

AN INDIAN ENGINEER'S PREDICAMENT.

The artist has drawn the scene graphically enough, but a railroad man *might* make the criticism that the curve which he has put in his picture would be, in real practice, almost as dangerous to a train as the tiger is to the unhappy engineer who confronts him so unwillingly.

THE PROPOSED LONDON TOWER.

SOME time since the Tower Company, of London, advertised for designs for a tower, the height of which was intended to exceed considerably that of the Eiffel Tower—984 ft.—and which was to be used substantially for the same purposes—that is, as a point from which visitors could obtain a very wide view and to which they would be attracted for that purpose, and which would be a marked point for all sightseers. Prizes of $2,500 and $1,250 were offered for the best and second best designs, and the decision was to be made by a jury of engineers.

In response to this offer 68 designs were sent in, of very

varying merit, some of them being, as the Jury stated in its report, "wildly eccentric or extravagant, while others were marked by an entire absence of architectural merit." In fact, the Jury say, "We must confess to a feeling of disappointment on the whole as to the result of the competition, there being no single design which we could recommend as it stands for execution. In justice to the competitors it must be remembered, however, that the existence of the Eiffel Tower and the desire to avoid imitations necessarily enhanced considerably the difficulties of the problem, because in the Eiffel Tower the most natural and obvious way for combining economical construction and suitable architectural effect had already been appropriated."

The Jury awarded the first prize to the design shown herewith in fig. 1, which was the work of A. Stewart, J. M. Maclaren and W. Dunn, of London. This design is for a tower 1,200 ft. in height, with an octagonal skeleton base 300 ft. in diameter. The tower is to be built of steel throughout, and to have steam elevators running to the top.

The second prize was given to the design shown in fig. 2, which was submitted by John J. Webster and J. W. Haigh, of Liverpool, and which is for an octagonal steel tower 1,300 ft. in height with a base 470 ft. in diameter. Hydraulic elevators are proposed, and the lower part of the tower and the upper platforms are provided with buildings for such purposes as may be desired.

The third design received honorable mention from the jurors, and is shown in fig. 3. It is the work of Max am Ende, of London, and presents a design for a tower 1,550 ft. in height, of the Gothic school of architecture and constructed of steel, with a platform 1,000 ft. above the ground, which is treated as the principal one, and upon which the upper part of the tower is constructed. The elevator consists of a train of carriages moving between vertical guides, while a driving carriage below the train runs upon a spiral railroad, having a grade of 1 in 5½. Elevators may be placed in one or all of the four main columns.

For the engravings given we are indebted to *Industries*. From the appearance of the three *best* designs it seems as if the jurors' criticism was fully justified.

We must admit, however, as the jury did, that to make an original design combining structural strength and architectural elegance is no easy task, and perhaps the plans submitted are as good as might have been expected.

FIG. 1.

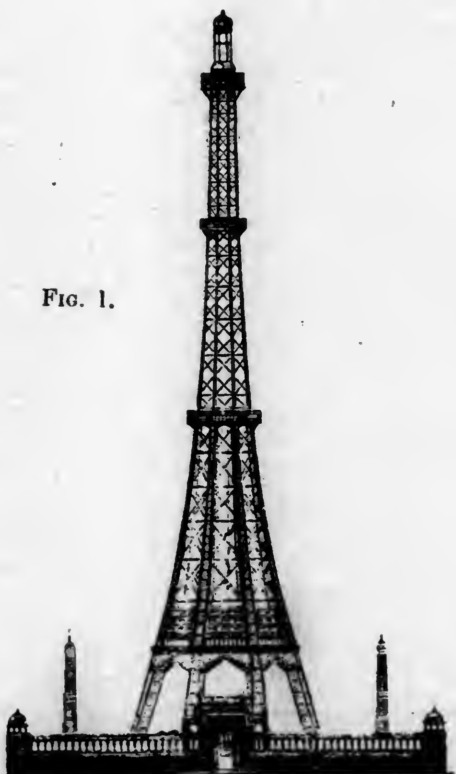


FIG. 2.

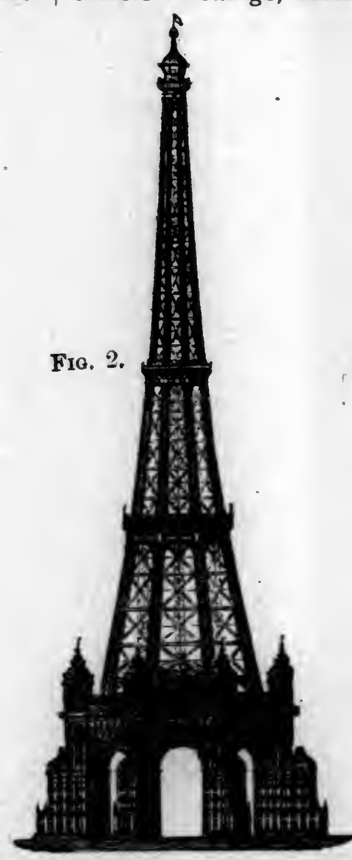
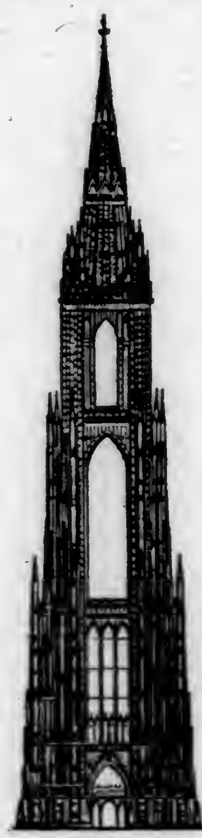


FIG. 3.



AERIAL NAVIGATION.

By O. CHANUTE, C.E., OF CHICAGO.

(A lecture to the students of Sibley College, Cornell University; delivered May 2, 1890.)

(*Continued from page* 318.)

FRENCH WAR BALLOON, 1884–1885.

THE aeronautical establishment of the French War Department, at Calais, was reorganized in 1879. There had been a similar establishment under the first French Republic, which had rendered some service by observing the enemy from captive balloons, but it had been disbanded. The new organization, which was chiefly intended to manufacture and man captive balloons, was in charge of able men, who had sufficient means to experiment, and the advantage of knowing all that had been accomplished by their predecessors. Giffard had pointed out the path, Dupuy de Lôme had gone into the mathematics of the question in an elaborate memoir, and Tissandier had exhibited the advantages of electric motors. The French officers in charge, Messrs. Renard and Krebs, improved very greatly upon all previous practice, and built, in 1884, an elongated balloon 165 ft. long by 27½ ft. in diameter, in which the largest section was no longer placed midway of the spindle, as in all previous attempts, but toward its front end, as obtains in the case of birds and fishes. Moreover, they placed the screw in front instead of behind, as previously practised; but the great improvement consisted in largely increasing the energy of the motor in proportion to its weight. Besides this, they obtained stability and stiffness by the use of an internal air bag and a better mode of suspension, and they enclosed the whole apparatus in a shed, so that it might be kept permanently inflated and await calm days for experiment.

This air-ship, which was named *La France*, held 65,836 cub. ft. of hydrogen, and its lifting power was 4,402 lbs. The car was very long (105 ft.), in order to equalize the weight over the balloon and yet admit of both being placed close together, in order to bring the propelling arrangements as near the center line of gravity as possible. The screw was placed on the car; it was with two arms, and 23 ft. in diameter. The power of the motor was ascertained by experiment in the shop to amount to 9 H. P.,

and speeds of 17 to 20 miles per hour were expected with 46 revolutions of the screw. Fig. 4 represents this air-ship.

The first trial was made on August 9, 1884, and on a calm afternoon the balloon ascended, proceeded some 2½

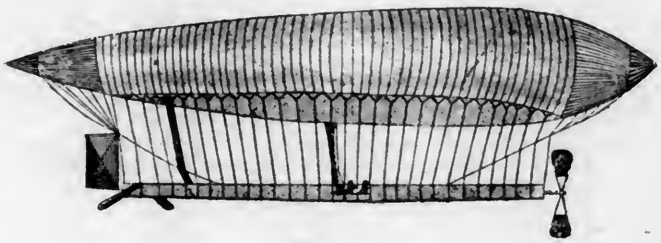


Fig. 4.

miles from the shed, and returned to its original starting-point, having proved perfectly manageable, and attained a speed of 10½ miles per hour. This was the first time that a navigable balloon had returned to its landing, and the experiment attracted great attention on account of it being, a few days thereafter, presented to the French Academy of Sciences. The aeronauts believed they could make still greater speed, but for obvious reasons they jealously guarded such details of construction as were not apparent from casual inspection in the air, and more particularly the construction of their motor and battery, concerning which more will be said hereafter.

A second ascension was made on September 12, 1884 (14 days before the last ascension of Tissandier), but although a speed of over 12 miles per hour was attained, an accident to the machine (heating of journals) compelled landing at Velizy, instead of returning to the starting-point. The latter was, however, successfully accomplished again, November 8 following, when two ascensions were made on the same day, and a speed obtained of 13.42 miles per hour.

Various minor improvements were made in the apparatus, and in the ensuing year three more trial trips were taken, making seven in all, on five of which the balloon returned to its starting-point, as follows :

SCHEDULE OF TRIAL TRIPS OF "LA FRANCE."

No. of Trial.	Date.	Rev. of Screw.	Speed, Miles per Hour.	Remarks.
1	August 9, 1884.	42	10.24	Returned to Chalais.
2	Sept. 12, 1884.	50	12.19	Accident—descent at Velizy.
3	Nov. 8, 1884.	55	13.42	Returned to Chalais.
4	Nov. 8, 1884.	35	8.54	" " "
5	August 25, 1885.	55	13.42	High wind ; descent at Villacoubray.
6	Sept. 22, 1885.	55	13.42	Returned to Chalais.
7	Sept. 23, 1885.	57	14.00	" " "

From these experiments, which, it must be remembered, were tried merely to test the efficiency out of doors of a new war engine, Captain Renard, while stating that the resistance was greater and the speed less than he had at first expected, deduced the following formulæ :

$$(1) \qquad R = 0.01685\, D^2 V^2$$

$$(2) \qquad W = 0.01685\, D^2 V^3$$

$$(3) \qquad T = 0.0326\, D^2 V^2,$$

in which

R is the air resistance to motion in kilogrammes.
V " " speed in meters per second.
D " " diameter of the balloon.
W " " work done in kilogrammeters.
T " " " " on the shaft of the screw.

From this he calculates that a balloon 32.8 ft. in diameter would require 43½ H. P. to drive it at 22 miles per hour.

Since 1885 no outdoor experiments have been made so far as the public is aware, but it is understood that numerous experiments have been actively carried on within doors, which, being intended to improve a war engine, have been surrounded with profound mystery.

A year or so ago this policy of secrecy was apparently changed, and Commandant Renard began publishing a number of scientific papers upon various branches of the subject, such as the resistance of air, his experiments with aerial screws, the possibility of success with aeroplanes and the construction of his primary battery, which, after having been kept secret for a time, he now fully describes and figures, with the remark that "this publication now threatens no danger to the national security," from which it is not unreasonable to infer that he has found a more efficient motor, and that it is not electric ; for he says further : "In the actual condition of industrial electricity, it is impossible that an electrical balloon shall constitute a true war engine."

At the Paris Exposition of 1889, the War Department erected a special building, and exhibited the air-ship *La France*, together with all its belongings, including the motor, battery, screw, etc., and full accounts of these exhibits have been published in various technical journals.

And yet the impression was produced on many minds while in Paris, more perhaps from what was not said than from what was shown and published, that the French War Department was, even now, in possession of important improvements and information which will afford increased speed, but which, as is right and proper, are kept secret, to prevent their use by possible enemies.

Should this conjecture be correct, it is not impossible that, in case France should be involved in a European war, we should soon see navigable war balloons flying at the rate of 25 to 30 miles per hour, going out over the enemy's lines on reasonably calm days to observe his positions and to drop an occasional explosive on his head. Indeed, in some of his writings, Commandant Renard, after laying down that "the conquest of the air will be practically accomplished when a speed of 28 miles per hour is obtained," expresses the opinion that we are on the eve of freely navigating the air, and that probably France will possess the first aerial fleet.

It is stated that the German, Russian and Portuguese Governments have recently organized aeronautical establishments, and are experimenting in secret. Should some notable success follow, it will not be the first time that a great invention has been advanced by the necessities of war.

Leaving speculation, however, the accompanying table gives the principal data as to the four air-ships which have

SCHEDULE OF NAVIGABLE BALLOONS.

DATA.	Giffard, 1852.	Dupuy de Lôme, 1872.	Tissandier, 1883.	Renard & Krebs, 1884–85.
Length, out to out ....ft.	144.3	118.47	91.84	165.21
Diameter, largest section.... "	39.3	48.67	30.17	27.55
Length to diameter...proportion	3.67 to 1	2.43	3.04	6
Cubic contents..................ft.	88,300	120,088	37,439	65,836
Ascending power......... ..lbs.	3,978	8,358	2,728	4,402
Weight—Balloon and valves, "	704	1,255 5	374	812
" Netting and bands, "	330	396	154	279
" Spars and adjuncts, "	660	1,316.5	75	170
" Rudder and screw, "	....	165	....	193
" Anchor and guide rope............ "	176	308	110	....
" Car complete....... "	924	1,287	220	995
" Motor in working order........... "	462	2,000	616	1,174
" Aeronauts .... "	154	310	330	308
" Ballast and supplies "	567.6	1,320	849	471
" Total apparatus.... "	3,977.6	8,358	2,728	4,402
H. P. of motor..................	3	0.8	1.5	9
Weight of motor per H. P., lbs.	154	2,500	410	130
Speed obtained...miles per hour	6.71	6.26	6.71	14
H. P. required 25 miles per hour.........................	155	52 (?)	77	51
Motor lbs. per H. P............	3	38 (?)	8	23

been described, and the H. P. necessary to drive them at 25 miles per hour.

The last line shows how light a motor must be to produce 25 miles per hour without increasing the weight.

We will consider the all-important question of motive power after examining the probable requirements of apparatus heavier than the air.

(TO BE CONTINUED.)

UNITED STATES NAVAL PROGRESS.

THE contract for the tubulous boilers for the coast-defense ship *Monterey*, now under construction at the Union Iron Works, San Francisco, has been awarded to Charles Ward, of Charlestown, W. Va. The contract provides that three-fourths of the power for the vessel shall be furnished by tubulous boilers, and the Ward boiler has been decided upon, after a competitive test. All makers of coil and tubular boilers in the country were invited to submit boilers for this test, but the only competitors were Charles Ward and William Cowles, of New York. Cowles proposed to furnish the required power with six boilers, each having 47 sq. ft. grate surface and 1,998.5 sq. ft. heating surface, and weighing, in steaming condition, 12.65 tons. Ward proposed four boilers, each having 74 sq. ft. grate surface and 2,938 sq. ft. heating surface, and weighing, in condition for steaming, 15.80 tons. The Ward boiler tested was considerably smaller than this. It had 53 sq. ft. grate surface and 2,473.5 sq. ft. heating surface, the ratio of heating surface to grate surface being 46.67 : 1. In the Cowles boiler this ratio was 43.12 : 1.

The trial lasted 24 hours, the boilers being worked at 160 lbs., with 2 in. air pressure in the fire room. The trial board, of which Chief Engineer Loring was senior member, spoke very highly of the performance of both boilers, but found that the Ward boiler was best fitted for use in the *Monterey*. The four boilers will supply about 4,500 indicated H.P. The rest of the steam for the vessel will be supplied by two ordinary navy boilers, to be built by the contractors. A description of the Ward boiler will be found on pages 347 and 348.

TRIAL OF THE "PHILADELPHIA."

The official trial of the new cruiser *Philadelphia* took place June 26, the run being made over a 40-mile course marked out off Long Island, between Southampton and Block Island.

The vessels detailed to mark the course for the *Philadelphia* and to make current observations during the trial were ordered to arrange themselves as follows: On the range at west end of the 40-mile course, off Southampton, L. I., the *Dolphin*, and at intervals of ten miles the tug *Nina*, the coast survey steamer *Blake*, the *Petrel*, and last the *Essex*, at the east end of the 40-mile course, off Block Island. Current observations were to be made from each of these vessels every ten minutes during the four-hour trial and at the instant the *Philadelphia* passed. The different ships, owing to a fog, were unable to take their exact positions. The time required to turn beyond the end of the course before beginning the return run was to be thrown out, and only the time taken in running over the straight course was to be considered in estimating the speed.

At 12 h. 48 m. 26 s. the *Philadelphia* started on her course. The end of the first half of the run showed the elapsed time to be since the start 2 h. 6 m. 23 s. The exact distance run was 40.146 miles and the average speed over the course was therefore at the rate of 19.1 knots per hour. Only the two straight runs over the course were considered; but no change in the speed of the engines was allowable, and all the other conditions of the trial were continued during the turn.

The westward run over the course was made in 2 h. 0 m. 32 s., making the total time for the two runs, 80,292 miles in all, 4 h. 6 m. 55 s.; the apparent rate of speed was thus 19.512 knots an hour, or more than half a knot above the contract requirements. It is understood that the average boiler pressure during the run was 155 lbs. and the engines averaged 120 revolutions per minute.

The official statement makes the average speed for four hours' run 19.678 knots—or 22.65 miles—per hour, the engines and boilers working in a most satisfactory manner.

BIDS FOR NEW SHIPS.

The Navy Department announces that bids will be received until October 1 for four new ships, designated as "Coast-Line Battle-Ships Nos. 1, 2 and 3" and "Cruiser No. 12." These bids may be made for the ships on the Department plans complete, or on the builder's plans for either hulls or machinery. The battle-ships are to be completed within three years; the cruiser within 2½ years. Bids may be made for two battle-ships, or for one battle-ship and one cruiser; but no single bid will be received for more than two of the ships.

The plans are not yet fully completed, but were to be ready by August 1, when full specifications could be obtained by bidders.

The general plans are so far ready, however, that it may be stated that Cruiser No. 12 will be of 7,300 tons displacement and have a speed of 21 knots; a premium of $50,000 for each quarter knot over, and a penalty of $25,000 for each quarter knot below that speed are provided. The hull is to be of steel, not sheathed. An armored deck is to extend all fore and aft, being turned down on each side to meet the side of the vessel below the water line, having a maximum thickness of 4-in. over the engine and boiler spaces. An approved water-excluding material equal to woodite or cellulose is to be fitted along the sides forward and aft on the slopes of the protective deck. The electric-lighting plant should consist of three units, each unit having an engine, dynamo, and combination bed plate, the weight of which should not exceed 24,000 lbs. The weight of all fittings and stores of the installation, including search lights, should not exceed 30 tons. A conning-tower, with 5 in. armor, is to be fitted. The main battery is to consist of four 6-in. rifled guns, to be mounted in the open protected by heavy shields, weighing two tons each; eight 4-in. rapid-fire guns, mounted under the protection of the upper deck, having fixed segmental shields attached to hull four inches in thickness. Secondary battery to consist of twelve 6-pounders, six 1-pounders and two machine-guns. Two of the 1-pounders and one of the machine-guns are to be mounted on field carriages. There are to be four torpedo-tubes and discharging apparatus and 12 torpedoes. The coal capacity is to be 750 tons on 23 ft. draft. There are to be two masts with signal poles. The cost is not to exceed $2,750,000, excluding guns, ammunition, armor of turrets, barbettes, gun shields and armored tubes directly pertaining to the protection of the guns and loading positions.

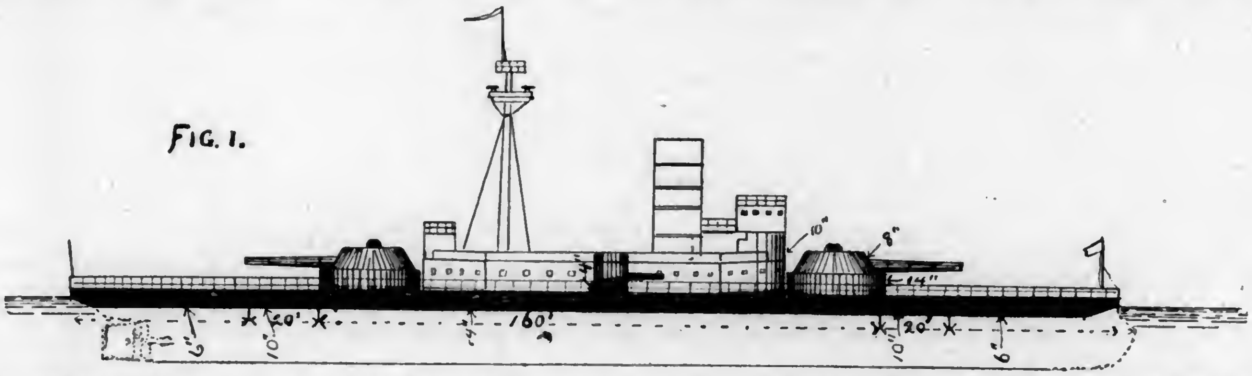
The coast-line battle-ships are to be about 9,000 tons displacement, and are to have a speed of 15 knots an hour, with premium of $25,000 and penalty of the same amount for each quarter knot above or below that speed. The hulls are to be of steel, with bracket framing; the armor belt is to be not less than 17 in. thick and 7 ft. wide. The transverse armor at the ends of the belt will be not less than 14 in. in thickness. The redoubts and turrets will have armor not less than 17 in. thick. The side from armor belt to the main deck will be protected by not less than 5 in. of steel armor. Coal is to be carried back of this 5-in. armor. An armored deck not less than 3 in. in thickness is to extend fore and aft from the ends of the armor belt, being curved down on each side to meet the side of the ship below the water. Over the side armor belt this steel will be not less than 2¾ in. in thickness. An approved water-excluding material equal to woodite or cellulose is to be fitted along the sides fore and aft on the slopes of the 3-in. protective deck. The battery to be carried is as follows: Four 13-in. breech-loading rifles, with their mounts and equipments; four 8-in. breech-loading rifles, with their mounts, shields and equipments; four 6-in. breech-loading rifles, with mounts, shields and equipments; sixteen 6-pounder rapid-fire guns; six 1-pounder rapid-fire guns and two gatlings, with all the necessary mounts and shields therefor. The 13-in. guns are to be protected by armor not less than 17 in. in thickness. The axes of the guns are to be not less than 6 ft. above the deck, and due regard must be paid to interference of fire and the effects of the blasts of the various guns. The 6-in. and 8-in.

guns will be protected by shields, but are to be protected in addition by barbettes, or otherwise carrying 4-in. armor for the 6-in. guns and 6-in. armor for the 8-in. guns, and the ammunition of the latter guns is to be supplied through armored tubes. Twelve torpedoes will be carried. There will be seven above water torpedo tubes, two forward, one aft, and two on each side. There will be a military mast, and a conning-tower protected by 10-in. plate. The coal capacity must be 400 tons on 24 ft. draft. An electric lighting plant is to be provided.

THE COAST-DEFENSE RAM.

Plans are being prepared for the coast-defense ram, of the type designed by Admiral Ammen. The total weight of armor on this vessel is estimated at about 770 tons, the greatest thickness being on the conning-tower, which will be 18 in.; deck armor will be 3 in. at center and 6 in. on the side; the upper side armor 6 in. and the lower 3 in. The general dimensions are: Extreme length, 243 ft.; breadth, 43 ft. 6 in.; breadth at water-line, 40 ft. 6 in.; extreme depth, 21 ft.; mean draft, 15 ft. 6 in., which can

FIG. 1.



be increased to 17 ft. 6 in. The displacement at ordinary draft will be 2,160 tons, or at 17 ft. 6 in. draft, 2,530 tons. The engines will have 4,800 H.P., and the estimated speed at full power is 18 knots an hour.

THE DEVELOPMENT OF ARMOR.

BY FIRST LIEUTENANT JOSEPH M. CALIFF, THIRD U. S. ARTILLERY.

(*Continued from page* 302.)

XIV.—RECENT PROGRESS IN THE UNITED STATES.

THE Italian armor trials at Spezzia, in 1876, closed the first epoch in the development of armor. The superiority of the hard-faced over the wrought-iron armor plate was so clearly demonstrated by these experiments that the latter was, as if by the common consent of the armor-makers of the world, abandoned. With scarcely an exception, every iron-clad laid down since that date has been provided with either steel or steel-faced armor.

For 10 years after the close of the Civil War no steps were taken toward the building of iron-clad ships of any kind. The war had left us with a large number of the monitor type of iron-clads, together with the *New Ironsides* and the *Roanoke*. The former was burned at League Island soon after, and the latter disappeared from the Navy list in 1883. Leaving out of account the Western river flotilla, a greater part of which disappeared with the ending of the war, the formidable list, so far as numbers went, of our iron-clad fleet then upon the rolls, had, at the end of the first decade, been reduced one-half.

Upon this list were five double-turreted monitors destined to become the subject of much controversy and of many reports, and of various attempts to improve and rebuild, and finally to figure, in name at least, among the modern iron-clad fleet of the country. These were the *Puritan, Miantonomoh, Monadnoc, Amphitrite* and *Terror*. Built originally of wood their rapid deterioration followed as a matter of course. In 1874–5 it was decided either wholly or substantially to rebuild them, giving them iron hulls.

The work of restoring these vessels went on so slowly, however, that in 1882 an Act of Congress made it obligatory upon the Naval Advisory Board to report as to the wisdom and expediency of completing them. So strongly in favor of completion was this report that work upon them was resumed at once and they were launched in the following year. In the new constructions the central spindle of the original monitors, about which the turrets revolved, disappeared, and rollers under the base of the turret were substituted.

The Act of August 5, 1882, marks the first step taken in the United States looking to the employment of modern armor. This act provided for the building and fitting the turrets and pilot-house of the double-turreted monitor *Miantonomoh* with steel-faced armor. In the absence of any establishment in the United States capable of turning out armor plates of this description, recourse was had to foreign manufacturers, as had to be done in the case of steel forgings for heavy guns, and bids were invited. In November of the following year contracts were entered into with the firms of John Brown & Company and Charles Cammell & Company, of Sheffield, for compound armor plates for the turrets, pilot-house and armored stack of this vessel—the 7-in. iron side armor remaining as it was—all of which were delivered within the eighteen months following.

By March, 1885, the completion of the four remaining double-turreted monitors was well under way, and in the following year the construction of an armored cruiser and an armored battle-ship was provided for. The large amount of armor plate called for by the appropriations of these two years was a direct challenge to American metal-workers, as they were, by the terms of the acts of Congress, to be given preference, "provided contracts for furnishing the same in a reasonable time, at a reasonable price, and of the required quality can be made with responsible parties."

In response to the invitation for bids from home manufacturers for steel armor plates the Bethlehem Iron Company was, in June, 1887, awarded the contract for supplying the 6,700 tons for these six vessels, the delivery to begin two and one-half years from date of contract.

From this date—June, 1887—a supply of armor plate, as well as of forgings for heavy guns, of domestic manufacture was guaranteed, and since March, 1885, no contracts have been made abroad for either gun forgings or armor. The Bethlehem plant is now in working order and is one of the most complete establishments of its kind in existence, with hydraulic forging presses, heavy hammers, machinery and tools capable of turning out forgings for guns up to 16-in. caliber, and of steel armor plate of any required thickness.

It should be stated here that in the circular issued by the Navy Department in 1886, to the steel manufacturers of the country, it declared for steel armor. This decision was in accordance with the recommendations of the Gun Foundry Board of 1884, the Fortification Board of 1885, and the Senate Select Committee on Ordnance and War-Ships, whose investigations at home and abroad extended over both of these years.

The *Miantonomoh*, the first modern armored United States vessel, now about completed, is a low-freeboard, twin-screw iron-clad of the monitor type, with two roller-base turrets, each to mount two 10-in. breech-loading rifles. The turrets are protected by 11½-in. compound armor—one manufactured after the Ellis, the other after the Wilson patent. Her side armor is of iron. An armor belt, 6 ft. in depth extends the entire length, protecting all parts of the vessel, 2 ft. above and 4 ft. below the water-line, and has a thickness of 7 in. amidships, reduced to 5 in. at the ends. On top of the side armor an armored deck, 1¾ in. in thickness is worked for the whole length of the vessel. On top of the turret is placed the pilot-house, 9 in. in thickness. The smoke-stack is protected by 10½ in., and the ventilator by 9 in. of armor. A hurricane deck, well above water, connects the two turrets.

The armor of the other four double-turreted monitors is to be wholly of steel. According to the original plans the *Puritan* did not materially differ from the *Miantonomoh*, except as to the character, depth and thickness of her armor. These plans have since been revised and greatly changed. Instead of four 10-in. guns mounted in two roller-base turrets, the new *Puritan* will have the same number of 12-in. rifles mounted in barbette-turrets, and the high, light hurricane deck is replaced by a solid superstructure built between the barbette-turrets, affording room for offices and officers' quarters, and within and on top of which the secondary battery is mounted. The armor belt is 5 ft. 7 in. in depth, with a maximum thickness amidships of 14 in., to a point 12 in. below the water-line, and thence tapering to 6 in at the armor shelf, and for a length of 160 ft.—sufficient to give protection to the engines, boilers, magazines, etc. Forward and abaft of the central section for 20 ft. the armor is reduced to 10-in. in thickness, tapering to 6-in. at the bow and stern. This armor is strongly backed with wood and strengthened by rigid frames and girders. The guns are to be mounted on turn-tables within fixed barbettes having 14-in. steel armor upon an 8-in wood backing. Sloping turn-table shields of steel, 8 in. in thickness, inclose the guns and afford protection to the gunners. The guns of the secondary battery mounted on the superstructure are protected by 4-in. armored barbettes, built in as a part of this structure; those on top are provided with 2-in. gun shields.

The pilot-house, containing the steering gear, speaking tubes, etc., is immediately abaft the forward barbette, and is provided with 10-in. steel armor. The main deck is protected with two thicknesses of 1-in. plating. The distribution of armor on this vessel is shown in fig. 1.

The *Amphitrite* is to be finished upon substantially the same plans adopted for the *Puritan*. The plans upon which the *Monadnoc* and *Terror* are to be completed have not, so far as I am aware, yet been announced.

The most decided as well as the most important step taken by the United States in the building of iron-clad ships was authorized by the Act of August 6, 1886, wherein the building of an armored cruiser and an armored battle-ship, each of about 6,000 tons displacement, was provided for. The keels of these vessels were laid down last year, the former at the Brooklyn and the latter at the Norfolk Navy Yard. Both are now well under way, and as the pioneers of American iron-clad ship-building deserve brief mention.

The disposition of the armor on the armored cruiser, the *Maine*, is shown in the accompanying cuts, fig. 2. A water-line belt of vertical armor, extending 180 ft. amidships, affords protection to the vitals of the ship, with a depth of 7 ft.—3 ft. above and 4 ft. below the water-line. This has a thickness of 11 in. from the top to 1 ft. below the water-line, tapering from thence to 6 in. at the armor shelf, upon a backing of 8 in. of wood. The ends of the armor belt are connected by athwartship armor-bulkheads 6 in. in thickness.

The four 10-in. rifles of her main battery are to be mounted in revolving turrets, and protected by 10½ in. of steel armor. The bases of these turrets are to be further protected by oval-shaped fixed breastworks of the same material and thickness. The conning-tower will have 10 in. of armor, and to protect the steering gear, etc., an armored tube leading thence to the armored deck is to be provided. This armored deck will slope from the top of the belt at its after end, the slope being 4 in. thick. The under-water deck at the end will be 2 in. thick, protecting magazine and steering gear.

This vessel will be supplied with all the modern appliances in the way of steam steering gear, self-stowing anchors and electric lights. In addition to her armament she is to carry two 60-ft. torpedo boats.

Fig. 2.

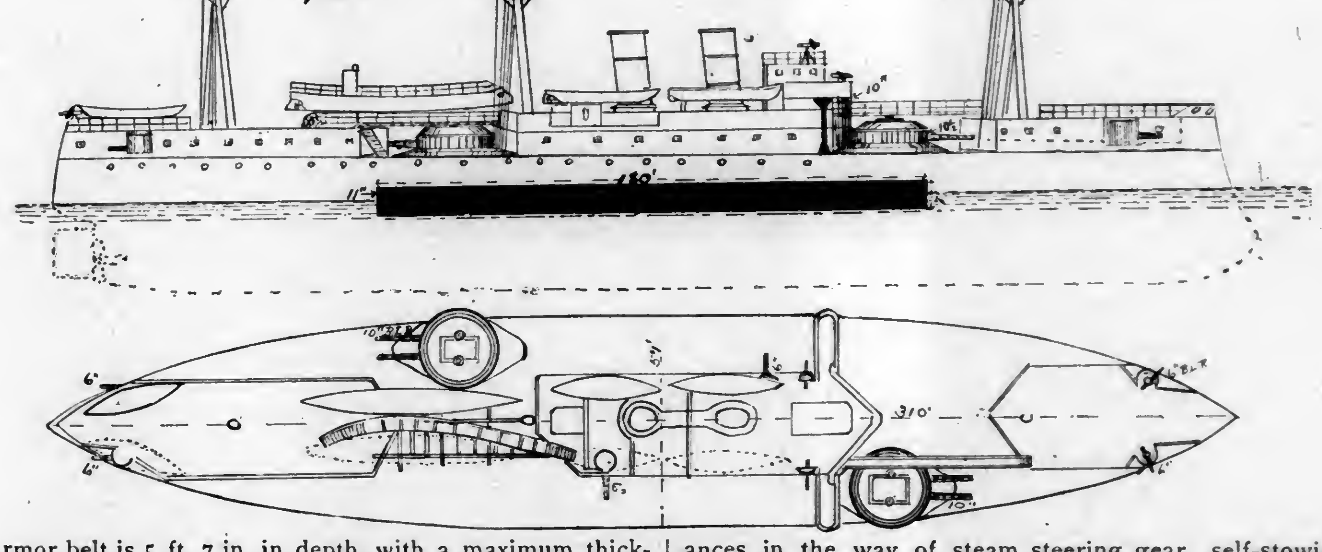


Fig. 3 gives, in a general way, the disposition of the armor on the battle-ship—the *Texas*. A steel armor belt, 12 in. in thickness will protect the vital portions of the ship, extending 2 ft. above and 4½ ft. below the water-line. This belt is to terminate at each end in a 6-in. steel breastwork, backed by 6 in. of wood, and extending diagonally across the vessel. A protective deck, 3 in. in thickness, is to be worked over the belt sloping down from the ends of the belt to the bow and stern. Each of the two 12-in. rifles of her main battery will be mounted in a revolving turret, 12 in. in thickness. The lower ports of these turrets, as well as the machinery necessary for working the guns, are to be inclosed in armored redoubts of the same thickness as the turrets. The conning-tower is likewise to have 12-in. armor, the ammunition hoists, 6-in. The six 6-in. guns of the secondary battery are protected by steel shields.

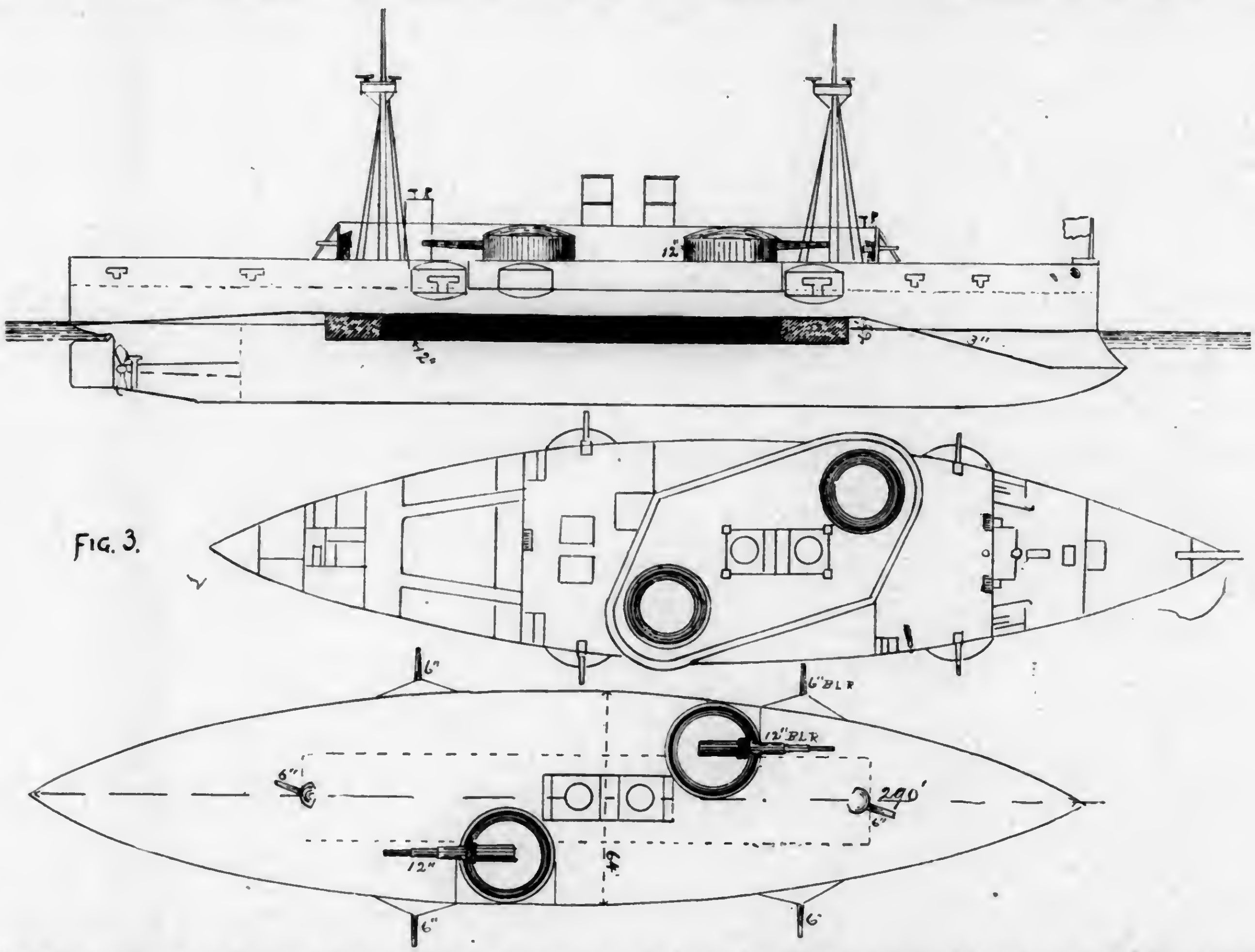
In addition to the *Maine* and the *Texas*, appropriations for the following armored vessels have been made: An armored coast-defense vessel of 4,000 tons; an armored cruising monitor of about 3,100 tons; a ram for harbor defense of 2,000 tons; an armored cruiser of 8,100 tons, and to this list has been added under the Appropriation Bill of the present year, three battle-ships. Of these, contracts for the armored cruiser and for the coast-defense vessel have already been made, and work upon the latter

has been begun by the Union Iron Works, San Francisco. The coast-defense vessel, designed under the direction of Secretary Whitney, is to be of low-freeboard, much after the type of the monitors, to be heavily armored and to carry a battery of one 12-in. and one 16-in. rifle in two fixed barbettes. The vessel can be submerged 18 in. for action. A belt of armor with a thickness of 16 in. amidships will protect the machinery, boilers and magazines, tapering to 6 in. at the bow and stern. The armor on the barbettes will be 16 in. for the 16-in. and 14-in. for the 12-in. gun. These barbettes will afford protection for the turn-tables, gun-slides, elevating and hydraulic gear, but, as in all barbette batteries, give no protection to the guns themselves and very little to the men who serve them. The pilot-house, smoke-pipes and tube for steering apparatus will be protected by 10-in, 6-in. and 6-in armor respectively.

The armored cruising monitor, commonly known as the "Thomas monitor," differs from the ordinary vessels of this type in having a turtle-back deck, and by an arrangement of tanks into which water can be admitted, so that her cruising freeboard may, for action, be reduced 3 ft. The arched deck of steel will have a thickness of 3 in. at the crown, turning downward at the sides to 4 ft. below the fighting-line, and increasing in thickness to $4\frac{1}{2}$ in. at the edges. The two 10-in. guns of her main battery will be mounted in a 10-in. roller-base turret. The base of the turret will have the further protection of a fixed breastwork of the same thickness. An elliptical bulkhead of 10-in. armor, rising from the armor-deck, affords protection to the air-pipes, ventilators and ash-hoists. A steel shield will protect her single 6-in. rifle. A secondary battery of rapid-fire guns with a 15-in. pneumatic dynamite gun, and two under-water torpedo-tubes, for firing torpedoes by gunpowder impulse, will complete her armament.

The armored cruiser, which with her 8,100 tons displacement approaches very closely to a battle-ship, will rely for protection against an enemy's shot more upon horizontal than vertical armor. The protective deck of steel will have a maximum thickness of 6 in. on the slope and 3 in. at the crown. This deck will be 1 ft. above the water-line amidships and slope to 5 ft. below water at the sides. The pilot-house, ammunition-hoists, etc., will be well protected, while the four 8-in. rifles of her main battery are to be mounted in 10-in. barbette turrets, and the guns of the secondary battery will be behind shields of an average thickness of 4 in.

The three battle-ships, for whose construction the Secretary of the Navy invited proposals within 24 hours after the approval of the Appropriation Bill by the President, will, when finished, compare very favorably, in armored protection and in armament, if not in tonnage, with the latest constructions in foreign services. The Act of Congress, under whose provisions these vessels are to be built, says, that the President is "authorized to have constructed by contract three sea-going coast-line battle-ships, designed to carry the heaviest armor and most powerful ordnance upon a displacement of about 8,500 tons . . . and to have the highest practicable rate of speed for vessels of their class, to cost, exclusive of armament and of any premiums that may be paid for increased speed, not exceeding $4,000,000 each."



Briefly stated, their armor-protection is to consist of a 7-ft. water-line belt of a maximum thickness of not less than 18 in.; the transverse armor at the ends of the belt of not less than 14 in.; the redoubts and turrets of not less than 17 in., and the sides above the belt to have not less than 5-in. steel armor; the deck armor is of 3 in. Coal protection and cellulose backing are also provided for. The armament will consist of four 13-in., 60-ton breech-loading rifles, four 8-in. and four 6-in. rifles, besides rapid-fire and machine-guns. In addition seven above-water torpedo-tubes are stipulated for.

It may be interesting to compare these vessels with the eight new battle-ships which the British Board of Admiralty decided upon building last November, and which are now under construction. Except in the matter of tonnage they approach very closely. Against the 14,000 tons displacement of the English ships ours have only 8,500, but the

guns of their main batteries are the same in number and of about the same caliber, with a slight advantage in favor of the English; but, as regards their secondary batteries, the ten 6-in. guns on each of the British ships are brought in comparison with the four 6-in. and four 8-in. on our own, with the number of quick-firing and machine-guns about equal, leaving with us a decided superiority in weight of metal. In the matter of armored protection each has

Name.	Type.	Condition.	Displacement, Tons.	Steel Armor. Ins.	
				Side.	Turret and Barbette.
Puritan	Low-freeboard turreted barbette	Awaiting completion	6,060	14	14
Amphitrite	Low-freeboard turreted barbette	Awaiting completion	3,815	8	11½
Monadnoc	Low-freeboard turreted barbette	Awaiting completion	3,815	8	11½
Miantonomoh	Double-turreted monitor	Awaiting completion	3,815	7*	11½
Terror	" " "	Awaiting completion	3 815	7	11½
Texas	Armored battle-ship	Building	6,314	12	12
Maine	Armored cruiser	"	6,648	11	10½
No. 2	" "	Contract awarded	8,100	†	10
Coast-defense vessel	Low-freeboard barbette	Building	4,000	16	16 14
Cruising monitor	Monitor	Plan not ready	3,100	5	10
Harbor-defense ram	....	Not yet designed	....	...	......
Three battle-ships	Armored battle-ships	Not yet begun	8,500	18	17

* Wrought-iron.

† Thickness of side armor not yet decided upon, but will be light.

18 in. of side and 17 in. of turret or barbette—the one steel, the other compound—as well as the 5-in. steel side armor above the belt, while in the thickness of the under-water deck and in the employment of coal, etc., for auxiliary protection to the machinery, the stipulations are almost identical.

In the five years that have elapsed since the United States entered upon the construction of iron-clad ships a showing has been made not at all discreditable. But it has been a beginning only, for as yet not a single armor-clad is in commission. The *Miantonomoh*, guns and all, is, however, very near completion. The five protected cruisers now in commission are, strictly speaking, armored ships, the armor being applied horizontally upon their decks instead of vertically upon their sides, but they are not so classified upon the Navy lists. The largest of them, the *Baltimore*, has an armored deck 2½ in. on its horizontal part and 4 in. on the slope. The conning-tower is built of 3-in. steel.

Herewith is given a list of the armored vessels for which appropriations have already been made. In addition to this list are the thirteen single-turreted monitors, which have been the subjects of numerous official investigations and reports, both favorable and otherwise, but which still remain upon the lists awaiting final action. Their 5 and 11-in. side and turret armor of wrought-iron is so inadequate to withstand the blows of modern projectiles that, as they stand, they can hardly be considered in counting the effective armored strength of the country.

(TO BE CONTINUED.)

THE ESSENTIALS OF MECHANICAL DRAWING.

By M. N. Forney.

(*Continued from page* 328.)

CHAPTER IV.—(*Continued.*)

GEOMETRICAL DRAWINGS.

The object of a mechanical drawing is to represent upon a plane surface the true form and proportions of one or more mechanical objects. It differs from ordinary drawing, which represents objects as they *appear* to the eye, or in "perspective," as it is called. This *appearance* does not always represent objects as they really are. Thus, if a person is standing on a straight railroad track, the rails appear to converge, or to be closer together in the distance than they are near to the observer, when, as a matter of fact, it is known that they are everywhere the same distance apart. The reason for this is due to the fact that light is reflected from different points to the eye of an observer in converging rays. To illustrate this, it will be supposed that a person whose eye is at A, fig. 108, is looking into the end of a piece of straight metal pipe, P, which is shown as though it was cut in half lengthwise. If a pane of glass, $p\,p$, was placed in front of the mouth of the pipe, and he should draw or paint on this glass the image of the pipe as he sees it, it would appear somewhat as shown in fig. 109, that is, the opening at the end $b\,b$ nearest to his eye would be represented by the large circles and that at the farthest end by a small one. The reason for this is that the rays of light pass from the ends of the pipe to the eye, as shown by the converging dotted lines $A\,b$, $A\,b\,A\,c\,A\,c$, so that the image produced on the glass by these rays, which come from the farthest end of the pipe, is much smaller than that produced by the rays from the nearest end. Most persons know that by looking into the mouth of a long tunnel that its farther end appears like a mere speck, and the rails appear to unite in a point. This diminution in the size of distant objects is, of course, in appearance only. As mechanical drawings are intended to give an absolutely correct representation of the size of objects, in such drawings the rays are supposed to pass from them to the paper on which they are drawn in parallel lines. Thus, if we were making a mechanical drawing showing an end

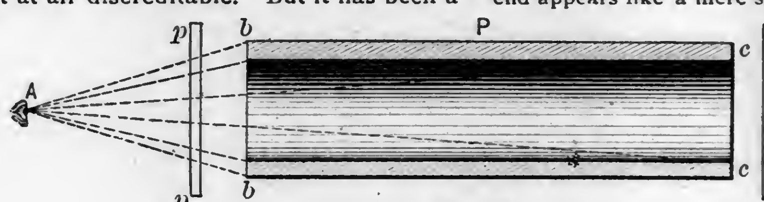


Fig. 108

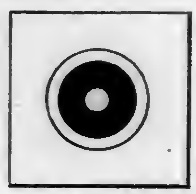


Fig. 109

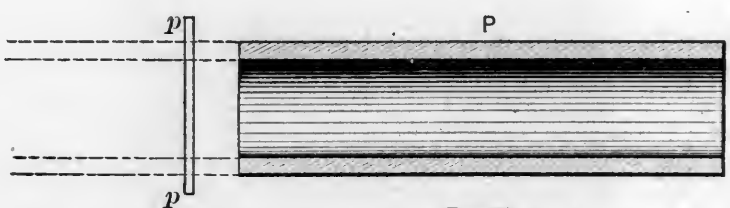


Fig. 110

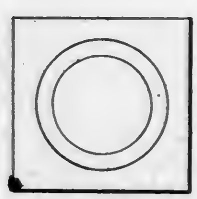
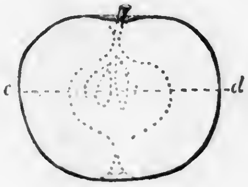


Fig. 111

view of the pipe *P*, fig. 110, the rays of light would be supposed to pass in straight parallel lines from it to the glass *p p*, as indicated by the dotted lines. If this were the case the farthest end of the object would appear as large as the one nearest to the glass or paper, as shown in fig. 111. Such a view is, of

Fig. 112.


Fig. 113.


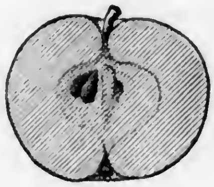
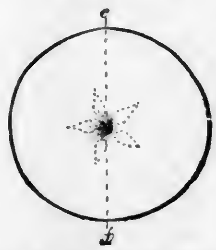


Fig. 115.

Fig. 114.


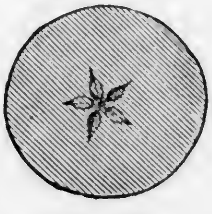


Fig. 116.

course, purely imaginary, but it serves the purpose of representing objects in their true form and proportions, which is very essential if the drawings are intended—as they usually are—to guide some one in making that which is represented. To all such drawings the general title of *geometrical drawings* is given, as distinguished from perspective drawings.

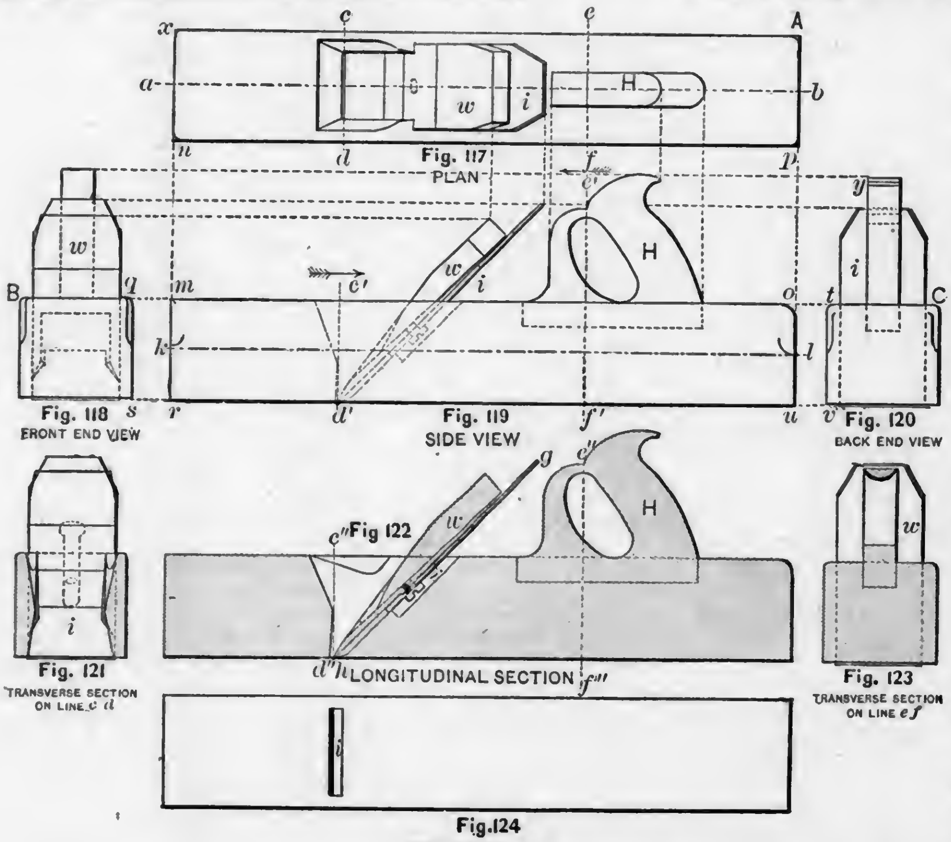


Fig. 117 PLAN

Fig. 118 FRONT END VIEW

Fig. 119 SIDE VIEW

Fig. 120 BACK END VIEW

Fig 122 LONGITUDINAL SECTION

Fig. 121 TRANSVERSE SECTION ON LINE *c d*

Fig. 123 TRANSVERSE SECTION ON LINE *e f*

Fig. 124 INVERTED PLAN

To give a complete idea of the form and proportions of an object, it is often important to give several different views of it. Thus, if we were drawing an apple and wanted to show it as it appears when looking at it from one side, it would be as shown in fig. 113, which is called a *side view*. If we represent it as it would appear if we were above it and looking down on it, it would be shown in fig. 112, which is called a *top view* or *plan*, and if the apple were turned upside down and represented in that position, as in fig. 114, the drawing would be called an *inverted plan*.

If we want to show the inside of the apple, say the seeds and core, we could represent it as it would appear if cut in half vertically, as shown by fig. 115, which is called a *section* or *sectional view* of the apple. It is evident, too, that it might be desirable to show the arrangement of the seeds as they would appear if the apple was cut through in the other direction, say on the line *c d*, fig. 113, and as shown by fig. 116. There are, therefore, two kinds of sections: one, fig. 115, in which the object is supposed to be cut through vertically, and therefore called *vertical sections;* the other, fig. 116, in which the object is supposed to be cut through horizontally, and therefore called a *horizontal section*, or *sectional plan*. In order to distinguish the parts which are represented as though they were cut in two from those whose surfaces only are represented, it is customary to shade sectional views with parallel lines, as shown in figs. 115 and 116. Sectional surfaces are also sometimes represented by solid black surfaces, or in drawings, by colors, as will be described in a future chapter.

It is often desirable in drawings to show on an exterior view of a machine or other structure some internal parts which would be hidden from view in the object itself. In such cases the interior parts are represented by dotted lines in mechanical drawings. Thus, to show the position and form of the seeds of the apple in figs. 113 and 114, they are represented by dotted lines.*

The appearance of any object, whether it be an apple or a piece of mechanism, of course depends upon our position in relation to it. Thus, fig. 119 represents a side view of an ordinary carpenter's plane. Obviously we can look at this plane from the top and represent it as shown in fig. 117, which, as explained, would be a top view or *plan;* or we might look at the front end of it, as shown in fig. 118, which is a *front view* or *front elevation;* or at the back end, as represented in fig. 120, which is a *back end view* or *rear elevation.* If it is desired to show the construction and arrangement of the interior parts, as the bit *i* and wedge *w*, we can show the plane as though it was cut in two lengthwise on a vertical plane coinciding with the line *a b* of fig. 117. Such a view is shown by fig. 122, and is called a *longitudinal section.* To show the internal parts more perfectly, it might be desirable to show as though it was cut in two crosswise at one or more points. Thus, to show the form of the bit *i* and wedge *w* it may be supposed that the plane is sawn apart on the line *c' d'* of figs. 119, and that we are then looking at the part which has been cut away, or in the direction of the dart *c';* and we would then have a view like that shown in fig. 121, which is called a *transverse* or *cross-section;* or that it is cut on the line *e' f'* of fig. 119 and that we are looking at the front part which has been cut away, or in the direction of the dart *e'*. We will then have a view like fig. 123, or another *cross-section.* In a section of this kind the direction in which we are looking often makes considerable difference. Thus, in the section taken on the line *c' d'* of fig. 119 if we are looking backward we see the wedge *w* and the bit *i*, whereas if the view was made looking forward the bit and wedge would not be seen. It is, therefore, often important to indicate from which direction the section is drawn. It would also be possible and is often desirable to make one or more horizontal sections. That is, we may imagine that the object is sawn apart on a horizontal plane coinciding with the line *k l*, fig. 119, and that we are looking down on the lower portion thus sawn off. Such a view would be a *sectional plan*, but is not shown in the engraving. In fig. 124 the plane is supposed to be turned upside down, and we are looking at the bottom of it, and we have an *inverted plan.*

As explained in relation to the different views of the apple, illustrated by figs. 112–116, if it is desirable to show the internal

* "Catechism of the Locomotive. Revised and enlarged."

parts of an object on an external view, it may be done by dotted lines. The fact that the lines are dotted indicates that the parts represented are below the surface and hidden from view. In figs. 118, 119 and 120 part of the bit i, wedge w and handle H of the plane are represented by dotted lines.

The arrangement of the different views on the paper is a matter of some importance, although it is thought that some writers and draftsmen have exaggerated it very much. If we draw a side view of an object, as fig. 119, the most convenient position to put the plan is immediately above or below it, because by placing the T-square and triangle on the board we can project nearly all the horizontal dimensions of the side view to the plan without laying them off with a scale. Much time is saved in this way. Thus, by placing the base of the triangle against the blade of the T-square and bringing the perpendicular side to coincide with the front $m\ r$ of the plane in the position indicated by the dotted line $m\ n$, we can draw the front end $x\ n$, shown on the plan, without measuring. The same thing can be done at the back end $o\ u$ and $A\ p$, or the horizontal position of any line or point can be transferred from fig. 119 to the plan above it by the triangle. In the same way the horizontal positions of lines or points may be transferred from fig. 119 to the longitudinal section, fig. 122, or to the inverted plan, fig. 124. In a similar manner the vertical positions of lines and points may be transferred from the side view, fig. 119, to the end views, figs. 118 and 120, by the T-square. Thus, by placing its blade so as to coincide with the top $m\ o$, we can draw the top $B\ q$, fig. 118, or $t\ C$, fig. 120. In the same way other lines and points may be transferred from the one view to the other as indicated by the horizontal dotted lines. A little experience will soon teach a learner the most convenient position in which to place the different views of an object in a drawing of it. It is often determined by some special circumstance, such as the size of the paper, and is usually not a matter of very great importance.

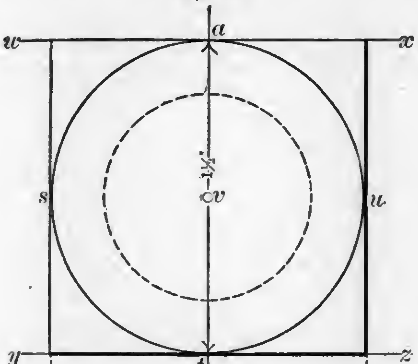
CHAPTER V.

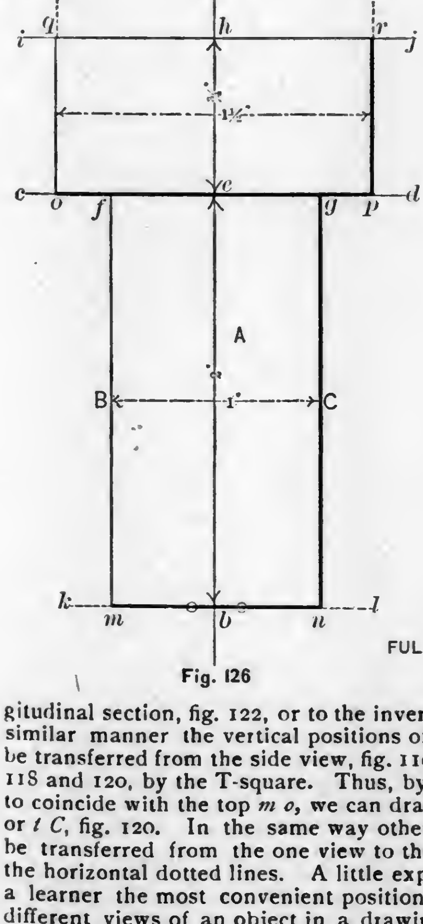
ELEMENTARY PRACTICE.

As a first example of mechanical drawing, we will take an ordinary bolt which has not been turned. It will be supposed that it is 1 in. in diameter "in the rough," as it is called, that is, as it is forged by the blacksmith; that it is 3 in. long, measured below the head, which is square, and is $\frac{3}{4}$ in. thick, lengthwise to the bolt, and $1\frac{1}{2}$ in. wide between the flat sides. In making a drawing of any symmetrical or nearly symmetrical object, it is always best to begin by drawing a center line and then lay off all its parts from this line. By this method any inaccuracies which are laid down in the drawing are confined to one measurement, whereas if a number of dimensions are laid down successively from each other, the errors are liable to be added together and they thus amount to a considerable and objectionable aggregate. By working from a center-line there is always a true starting-point for each dimension laid down.

Therefore, a vertical center line $a\ b$, figs. 125 and 126, should be drawn with a pencil and the aid of a triangle and T-square. At any convenient point on this line draw with the pencil and T-square an indefinite line, $c\ d$, fig. 126, at right angles to $a\ b$. If the bolt is to be drawn full size set a pair of dividers from a rule or scale so as to take accurately one-half the diameter of the bolt $= \frac{1}{2}$ in. between its points. Then, from the intersection e of $a\ b$ with $c\ d$, set off on $c\ d$ with the dividers the distances $e\ f$ and $e\ g$ each equal to half the diameter of the bolt. In the same way with the dividers set off from e a distance $e\ h = \frac{3}{4}$ in. or the thickness of the head, and $e\ b = 2$ in. the length of the bolt. Then, through the points h and b draw with a pencil the indefinite lines $i\ j$ and $k\ l$ and through the points f and g the perpendicular lines $f\ m$ and $g\ n$. From e lay off $e\ o$ and $e\ p$, each equal to half the width of the head of the bolt and draw the perpendicular lines $q\ o$ and $r\ p$ through the points o and p. This will complete the side view of the bolt. It should be mentioned that the dimensions may be set off on the paper directly from the scale, and it is often most convenient to do so, but more accuracy is possible if dividers are used, especially for dimensions which are not too great to be conveniently taken between the points.

Fig. 125

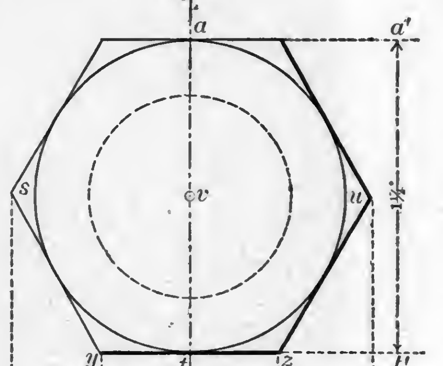




FULL SIZE

Fig. 126

Fig. 127



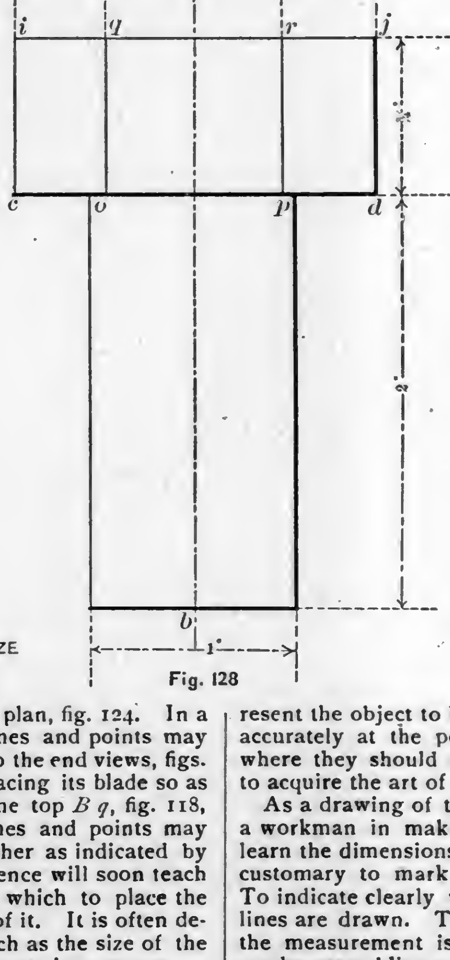


Fig. 128

To draw a plan or top view of the bolt, to show the form of the head, take one-half of its width with a pair of compasses and from any convenient point, as v on the center line $a\ b$, as a center and with this dimension as a radius draw a circle $a\ s\ t\ u$, fig. 125. Then, with the T-square, draw horizontal lines $w\ x$ and $y\ z$ tangent to this circle and with a triangle from $w\ x$ draw the perpendiculars s and u to $y\ z$. This, then, completes the plan, showing the shape and size of the head of the bolt. In order to show the form of its body or shank A, a dotted circle should be drawn from the center v with a radius equal to half the diameter.

Having made the drawing in pencil, it should then be inked in with a pen. In drawing with a pencil many of the lines, as $i\ j$, $c\ d$ and $k\ l$, must be of indefinite length until the drawing is completed and such lines as $q\ o$, $f\ m$, $r\ p$ and $g\ n$ are laid down, as these latter define by their intersections with $i\ j$, $c\ d$ and $k\ l$ the length which the latter should be. In inking in a drawing care should be taken to ink only the essential parts of the lines, or those portions which represent the object to be delineated. The ink lines should end accurately at the points of intersection with each other, and where they should terminate. Some practice will be needed to acquire the art of doing this neatly.

As a drawing of this kind is generally intended as a guide to a workman in making such bolts, it is important that he can learn the dimensions of it at a glance. With this in view, it is customary to mark all essential dimensions on the drawing. To indicate clearly to which parts the dimensions refer dotted lines are drawn. The dotted lines show the direction in which the measurement is made, and its limitations are indicated by marks resembling arrow points. Thus, in fig. 126, to show the diameter of the bolt a dotted line, $B\ C$, is drawn across the body or shank, and arrow points are placed at B and C, where the dotted line meets the lines $f\ m$ and $g\ n$. The diameter—in this case 1 in.—is then marked on this *dimension line*, as it is called, which shows that the measurement is to be made cross-

wise or diametrically, and the arrow points show that it is made from the lines *f m* and *g n*. If the figures represent feet a single mark is made after the figures, and if they represent inches, two marks are made. Thus, two feet and six inches is usually written on drawings thus, 2′ 6″.

The length of an object like that represented in the drawing is often marked on the center line, as *a b*. The length of the shank, from *e* to *b*, in this case 2″, is marked as shown and also the thickness of the head from *h* to *e* = ¾″. The width of the head = 1½″ may be marked on the side view, as shown in fig. 126, or it may be indicated on the plan, as in fig. 125 from *a* to *t*. In some instances dimension lines are carried out to one side of the drawing, as in figs. 127 and 128, and the dimensions and arrow points are placed as shown in these figures.

After the drawing is completed and the lines and figures are all inked in, the superfluous pencil lines are rubbed out. In figs. 125 and 126 the pencil marks are indicated by fine lines, but in figs. 127 and 128 they are supposed to be rubbed out.

It is often an advantage to have center lines from which measurements have been made represented on drawings, and therefore they are often inked in, as *a b* in figs. 127 and 128. To distinguish center lines from those which indicate dimensions or others which represent internal or hidden parts, the first may be represented by a series of long and short marks, as *a b* in figs. 127 and 128. Dimension lines are composed of a series of long dots and hidden parts are indicated by short dots.

Fig. 129 Fig. 131

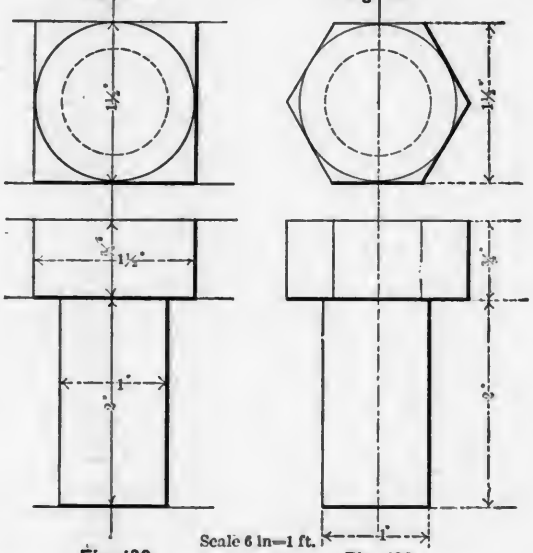
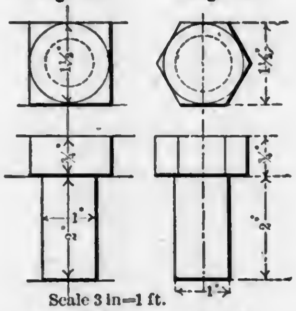


Fig. 130 Fig. 132

In figs. 127 and 128 a bolt is represented with a hexagonal head. The bolt is drawn in the same manner as has been described, excepting the head, for which some special directions are needed. To draw the head, take half the width *a t* of the

Fig. 133 Fig. 135



Scale 3 In=1 ft.

Fig. 134 Fig. 136

Fig. 137 Fig. 139

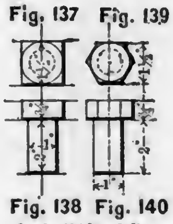


Fig. 138 Fig. 140

Scale 1½ In=1 ft.

head = ¾″ in the compasses and from *v* as a center describe a circle with the pencil. Then, by the method explained in Problem 29 in Chapter III., circumscribe a hexagon about this circle. Then having drawn the lines *i j*, fig. 128, place a triangle on the blade of the T-square so as to draw a vertical line and slide it along so that it will coincide with the corner of the head at *s*, fig. 127. The line *i c*, which represents that corner in fig. 128 may then be drawn along the edge of the triangle. In the same way by bringing the triangle so as to coincide with the corners *y*, *z* and *u* the lines *q o*, *r p* and *j d*, which represent these corners in fig. 128, may be drawn.

If instead of being drawn full size the bolts were to be represented half size, or to a scale of 6 in. = 1 ft., then in making the drawing the measurements must be taken from the scale, which is marked ½—that is, ½ in. on the scale represents an inch. The drawings, figs. 129–132, can thus be made in exactly the same way as figs. 125–128 were made, the only difference being that the measurements are taken from the ½ scale instead of a full-sized rule. If the drawings are to be ¼ size, or made to a scale of 3 in. = 1 ft., as in figs. 133–136, then the measurements are taken from the scale marked ¼ or 3 in. If they are to be ⅛ size, or made to a scale of 1½ in. = 1 ft., as in figs. 137–140, then the measurement must be taken from the scale marked ⅛ or 1½.

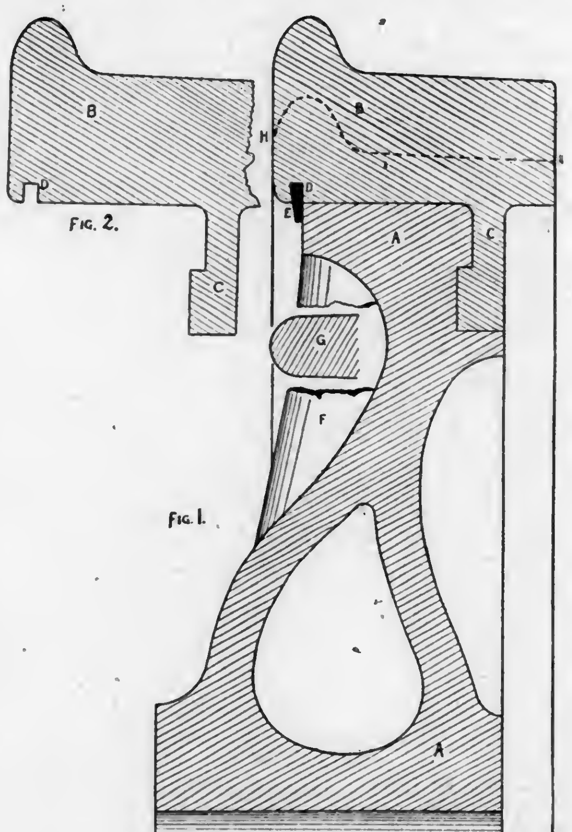
It should be remarked here that we may speak of a scale as either half size, as ½ in. = 1 in., or as 6 in. = 1 ft. In the same way a ¼ scale may be ¼ in. = 1 in. or 3 in. = 1 ft., and ⅛ may be ⅛ in. = 1 in., or 1½ in. = 1 ft. The triangular scales illustrated by fig. 7, which are intended for mechanical draftsmen, usually have scales of 3 in. = 1 ft. and of ¼ in. = 1 ft. It may be assumed of the latter that ¼ in. = 1 in. and drawings intended to be quarter size may be made either from the scale of 3 in. = 1 ft. or ¼ in. = 1 ft. The same remarks will apply to those of 1½ in. = 1 ft and ⅛ in = 1 ft. and to others on the triangular scale.

The student is advised to draw the bolts shown by figs. 125–128 to each of the four scales to which it is represented in figs. 125–140. The student cannot be too careful in his early practice to make all his measurements and lay them down on the paper with the greatest accuracy. No degree of precision which is attainable with the naked eye is too minute in making mechanical drawings. This is especially the case with drawings made to a small scale.

(TO BE CONTINUED.)

Snow's Steel-Tired Wheel.

THE engraving, fig. 1, represents a half-section of a steel tired wheel which is manufactured by the Ramapo Wheel & Foundry Company, of Ramapo, N. Y. The illustration shows that this



SNOW'S BOLTLESS STEEL-TIRED WHEEL.

wheel has the great merit of simplicity of construction. The tire is mounted on a cast-iron center of what is known as the "Washburn" pattern, which is made of the same material used

in making chilled wheels. These centers are also made with spokes, especially for locomotive trucks. Inside of the rim the Washburn form of wheel has a single plate, which divides into two as it approaches the hub, as shown in the engraving.

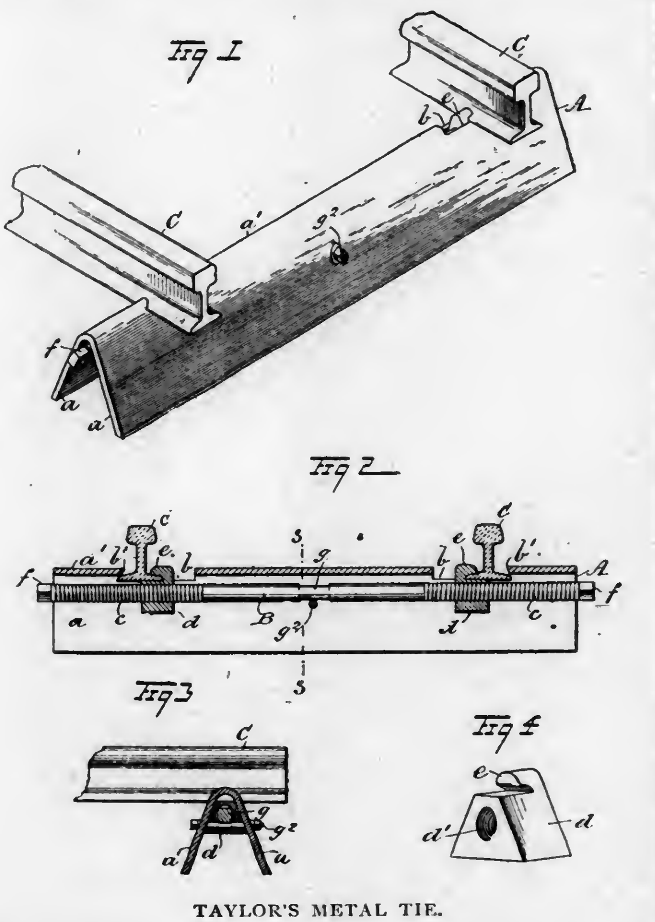
The tire is attached to the wheel by an internal flange *C*, which fits into an annular groove turned in the face of the wheel center. The tire is shrunk in the center, and is secured in its place by a ring *E* which is cut open and sprung into a groove *D* turned in the inner surface of the tire. The form of this groove when it is first turned is shown at *D*, in fig. 2. After the tire is shrunk on its center and the ring is sprung into the groove, the outside lip is hammered down, by special machinery designed for that purpose, so as to fit the ring perfectly, as shown in fig. 1. When this is done the ring, owing to its tapered form, is securely held in its place, and if the tire should break the flange *C* would hold it so long as the tire could not move outward on the wheel, which is prevented by the ring *E*. These wheels are made of three sizes—33 in., 36 in. and 42 in. in diameter—and, if simplicity of construction is an advantage, they have that merit.

The dotted lines in the section of the tire in fig. 1 show the distribution of the metal when the tire is turned down to its lowest safe limit.

Recent Patents.

TAYLOR'S METAL TIE.

FIGS. 1, 2, 3 and 4 show a metal tie invented by James P. Taylor of Fort Worth, Tex., and recently patented, the number of the patent being 428,869. Fig. 1 is a perspective view; fig. 2 a section; fig. 3 a transverse section on the line 3 3, fig. 2, and fig. 4 is an enlarged view of the clamp for holding the rail. The tie, as will be seen, is a metal plate bent into or rolled in



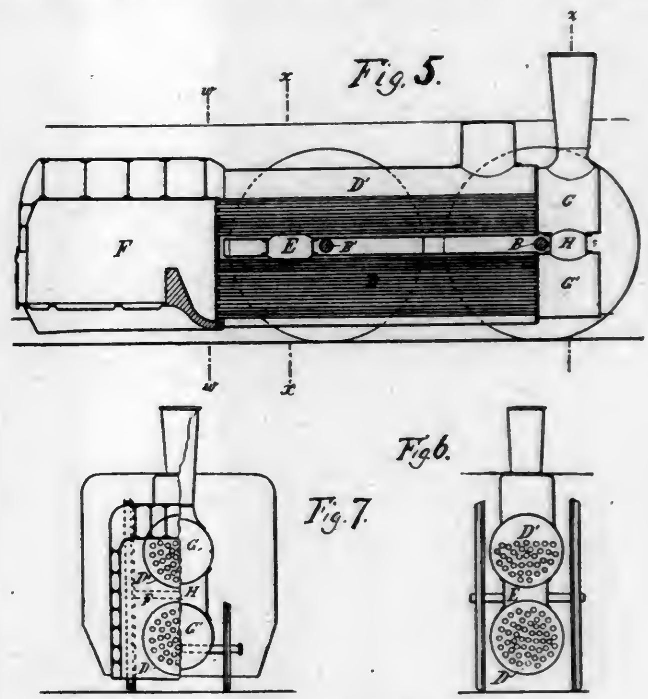
TAYLOR'S METAL TIE.

the form shown, with slots *b b* made at the apex, at the point where the rail should come. At the outer side on these slots, lips or flanges *b' b'* are formed in such a way as to hook over the base or flange of the rail when it is placed on the tie. The rails are held in place by the clamps *d d*, and through them passes an iron rod, *B*, having right and left hand screws cut upon the ends, as shown. The clamps are brought into and held in place by turning this rod with a suitable wrench placed upon the squared end *f*. A transverse bolt, *g*, is run through the tie, chiefly to hold up the rod *B* at the center and to keep it in place.

A CURIOUS LOCOMOTIVE BOILER.

Figs. 5, 6 and 7 show what may be considered one of the curiosities of the Patent Office. They represent the construction of a boiler, which is covered by patent No. 429,003, issued to Ala Berthy, of Buda-Pesth, Hungary, and can perhaps best be described in the inventor's own words, as follows:

"This invention relates to a construction of locomotive-boiler, more particularly for use with express-trains, by means



BERTHY'S LOCOMOTIVE BOILER.

of which greater speed can be obtained than was heretofore possible without reducing the stability.

"Fig. 5 is a longitudinal vertical sectional view of a locomotive-boiler embodying my improvements. Fig. 6 is a cross-section of the same on line *x x* of fig. 5. Fig. 7 is a cross-section taken on the right-hand side on the line *z z* and on the left-hand side on the line *w w* of fig. 5.

"The boiler consists of two cylindrical shells *D D'*, of which the one is situated above and the other below the driving-axles, and these shells are connected by a branch, *E*, situated behind the rear driving-axle. The fire-box *F* is common to both boiler-shells, and the smoke-boxes *G G'* of both are connected by a vertical branch pipe, *H*, in front of the front driving-axle. This connecting branch is fixed by screw-bolts, and can be removed, so as to enable the boiler to be removed from the framing when required, and also to facilitate the removal of the axles."

The Use of Aluminum in the Construction of Instruments of Precision.

(Note read before the American Institute of Mining Engineers at the Washington meeting, by William P. Blake.)

THE adaptation of aluminum to the construction of portable instruments of precision, where lightness is important, is well illustrated by the double reflecting and repeating circle, the invention of Captain Charles Hervey Townshend, of New Haven.

One of these instruments, now exhibited to the members, has just been completed by Stackpole & Brothers, of New York, and is made of aluminum, with the exception of a few minor pieces and a portion of the handle. This instrument is intended for use in a boat, and to be held in one hand like a sextant; and as it is a complete circle, lightness of the material becomes more important.

The whole instrument, as shown, exclusive of the eye-pieces and the handle, weighs only one pound, or about one-third of the weight of a sextant of the usual construction. The circle, about 9 in. in diameter, was cast in one piece from metal furnished by the Pittsburgh Company.

The mere inspection of this circle, and of the limbs of the in-

strument, is sufficient to show that the metal works well under the file, in the lathe, and under the graduating tool. The castings are homogeneous, free from blow-holes, and dress up clean and sharp. Every part, also, appears to have the requisite rigidity under the touch, although the extreme lightness raises a doubt of it in the mind.

There is also before the Institute another example of the use of aluminum in the construction of instruments by Fauth & Company, of Washington.

The great advantage of lightness in such instruments will be appreciated by those who have had to carry instruments of the usual construction through the devious passages of mines and up the sides of high mountains, where every ounce of weight is a grievous burden.

Another great advantage which aluminum has over brass is its resistance to corrosion by the atmosphere, moisture and even sea-water. It does not require a coating of lacquer, as all brass instruments do, and its unprotected surface keeps clean and bright where brass and ordinary bronze metal will corrode and become green and dirty.

But with these great advantages offered by the commercial aluminum, it is probable that it can be improved for general instrument work by the addition of a small amount of silver. The aluminum, it must be said, is rather soft for wearing parts, such as bearings and rubbing-surfaces, and it is perhaps not quite as rigid and stiff as it should be for some parts of instruments. The alloy shown here by Mr. Hunt, consisting of 95 parts of aluminum by weight and 5 parts of silver, while but a little heavier than the aluminum, is much more rigid and harder, and works quite as well, or better, under tools. The specific gravity is about 3.2, aluminum being 2.6. This alloy is whiter than the aluminum, more like silver, and withstands the corrosive action of the atmosphere and sulphur nearly as well. It takes a good polish, and works well under the graver. It is better for graduation.

The leading instrument-makers are yet very cautious in the use of the unalloyed aluminum. Messrs. Fauth & Company, of Washington, make considerable use of aluminum in astronomical apparatus, where great rigidity is not required and lightness is important, and which have careful handling. They find, in working the metal, that it is apt to tear under the tool, and that it does not give good clean threads. Others, however, who have worked with the metal, have overcome this last difficulty by a little care in the use of the tap and die.

The Keuffel & Esser Company, of New York, have been experimenting with aluminum in their shops, and have made some sextants of it which have proved to be satisfactory as far as the limited experience in the use of them has shown. They have also a mining transit of aluminum in construction, some portions of the instrument being, however, made of a harder and heavier metal.

While the unalloyed aluminum is no doubt soft and somewhat "spongy" in working, the evidence presented in the finished instrument exhibited at this meeting is sufficient to show that the metal and its alloys have great merit as materials for the construction of instruments of precision.

The Accident to the "City of Paris."

THE investigation into the accident to the steamer *City of Paris*, ordered by the British Board of Trade, resulted in a report and verdict, the essential part of which is as follows:

"In the judgment of the Commission, full provision was made to insure the safety of the *City of Paris* as an ocean-going steamer, and safety was in no way sacrificed to speed. We consider cast steel a proper and suitable material to be employed generally in the construction of the various parts of the engines hitherto usually made of cast iron. The propeller shafts, both inboard and outboard, appear to have been sufficiently supported. Those of the port engine showed little or no signs of wearing. The after bracket is properly constructed, and is of sufficient strength for the shafting and propeller it has to support. The bushes in the stern tubes and after brackets and the linings of the casings are of suitable material and are properly constructed. The cylinders, pistons, rods and other parts of the machinery are also of suitable material and well constructed.

"The bulkheads are sufficiently strong to stand any pressure, assuming that any two compartments are flooded at the same time, in any state of the weather. The longitudinal bulkhead between the engine rooms is of sufficient strength and is carried sufficiently high. The cracks in the cast-steel columns caused by contraction were repaired with steel plates in a very efficient and workmanlike manner.

"The primary cause of the casualty was the extraordinary wearing down of the brass in the bracket supporting the extreme end of the propeller shaft, whereby the end dropped about seven inches, producing a bending effect on the shaft at its forward support with each revolution. This probably produced finally a total fracture. The cause of the water finding its way into the compartments was that a large portion of the low-pressure cylinder fell against the condenser, tearing it away and thereby opening a large communication with the sea, through which the water rushed in such volume that before any of the inlets could be closed they became covered with water and out of reach. The water passed into the dynamo room and port engine room through the bulkheads, which were broken by the ruptured machinery, and into the two compartments by the injury to the valve box in the engine room.

"After the practically unanimous testimony of eminent authorities of the Board of Trade, Lloyds and other experts, upon the strength, completeness, and efficiency in all respects of the ship for the service for which she was especially designed and built, the Court does not consider itself in a position to offer suggestions thereon. During the course of the inquiry we had evidence that, even if some of the forward compartments of the ship had been filled with water in addition to those that were filled, she would still have had a fair amount of free-board, and would have been able to float, her mean draught on reaching Queenstown being only 8 in. more than when she left New York.

"We are of opinion, having regard for the trying ordeal through which she passed, that the vessel proved herself to be one of the finest and safest in the mercantile marine."

Without intending to make unfavorable comments on the ship, the Court suggests, as precautions which should be considered in future, the use of a governor to control marine engines; the improvement and strengthening of the supports for the outboard bearings of long propeller shafts, and the isolating of compartments as much as possible in all steamers.

Manufactures.

Aluminum in Portable Form.

A GREAT deal has been said lately about the properties of aluminum, and it really seems probable that the methods of extracting this metal may be so cheapened as to make it an article of commerce and bring it into ordinary use. There is no doubt that in this case it will be very widely used, since it undoubtedly possesses great strength, lightness and other properties which make it superior in many respects to the metals now in ordinary use for many purposes, while its value in forming alloys with other metals will be very great. But, while very many people have heard of aluminum, comparatively few have seen it, and this will make very interesting the business card which has lately been issued by the well-known firm of Valentine & Company. This card is made of pure aluminum and is about the size of a silver dollar. It is handsome in appearance, equal to silver, and the point which will attract attention at once is its extreme lightness. It really almost seems to contradict all our received ideas, for it hardly seems possible that a piece of metal, which feels lighter in the hand than a piece of paper, can be possessed of all the properties which this metal has.

Electrical Notes.

THE Westinghouse Electric Company of Pittsburgh has passed into the control of a new organization known as the Westinghouse Electric & Manufacturing Company, the organization being practically the same. The stock of the new Company is $10,000,000, or twice that of the old, and the old stockholders have the privilege of taking stock in the new Company. The assets, it is stated, are in excess of the capital stock. It is understood that the reorganization is effected and additional capital provided with the intention of going largely into the building of electric railroads and electric motors.

A PAPER read by Mr. M. B. Leonard, of the Chesapeake & Ohio Railroad, at the recent convention of the Railroad Telegraph Superintendents, refers to the use of electric lighting in railroad service. The employment of electric lights in freight and passenger stations is becoming general, but does not call for any special mention, as the methods employed do not differ from those in use in ordinary manufacturing establishments, public buildings and similar places.

The electric light has been tried for locomotive headlights, and it is now believed that the difficulty at first experienced, the constant vibration of the locomotive affecting the feeding mechanism of the lamp, has been overcome, and a light has

been obtained which can be relied upon. It may be mentioned, however, that authorities are not agreed as to whether it is desirable to have too brilliant a headlight.

The electric lighting of passenger trains has not so far made much headway in this country, although used to a considerable extent abroad. The storage battery system, which was tried by the Boston & Albany Railroad, has been abandoned by that Company, but the Pennsylvania Company still continues to light its parlor cars from storage batteries, and a similar system has been adopted by the Intercolonial Railroad of Canada on the through trains between Halifax and Quebec. The Pullman Company is using a combination of dynamo and storage battery, and the Chicago, Milwaukee & St. Paul Railroad Company is using on two of its trains a dynamo carried in a separate car.

The Southern Pacific Company is now using a large number of electric switch signal lights in its yard at Oakland, Cal., with much success. The electricity is supplied from the plant used for lighting the station and pier at Oakland.

An Improved Universal Trimmer.

The accompanying illustration shows a universal trimmer for the use of pattern-makers, coach-builders and other wood-

IMPROVED UNIVERSAL TRIMMER.

workers, which is manufactured by the Grand Rapids Machinery Company at Grand Rapids, Mich. In the cut *A* shows a block of wood, the size in this case being 2 × 10 in.; the knife is propelled through the wood by grasping the handle *E* and moving it toward the opposite end of the machine. This handle is adjustable to any one of five notches in the fulcrum *D*, which makes the operation of the machine more convenient. The fulcrum *D* is provided with a roller which works in the slot *F*, a device by which the power can be applied to the best advantage. The circular ways in which the carriage travels give a drawing stroke which can be seen at *C*, being the space between the bed of the machine and the bottom of the lower way. For instance, in trimming the end of a 1 × 12-in. board, 3 in. of the knife edge are used, thus distributing the wear on the knife instead of bringing it upon one point. The machine is provided with link stops *H*, which can be set when several pieces of one size are to be trimmed. The gauges *G* are always held in the same relation to the knife, no matter at what angle they may be set. They are hung in the bearings *B B* and can therefore slip away from the knife.

The advantages claimed over other forms of machine are the circular way, making the cut easier; the adjustable handle which can be placed to best suit the convenience of the operator; the weight; the link stops where several pieces are required; the pivoted gauges, positive in their action and needing no spring to keep them off the knives, and also forming a brace for the top frame; and the fact that the knives need no shields, as they do not project outside of the frame.

These machines are adapted to the use of almost all woodworkers and will be especially convenient for pattern makers. A number of different sizes are manufactured. The illustration shows one of No. 13, which weighs 150 lbs. and has a 12-in. stroke. We are informed that a number of these machines are now in use and have met with general approval wherever they have been tried.

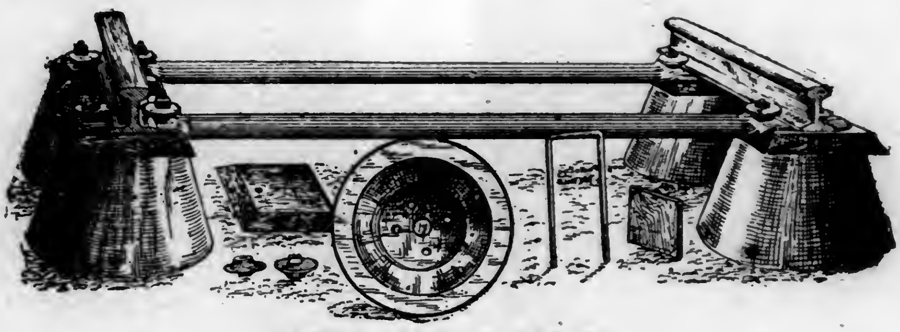
A Wrought-Iron Chimney.

The description of a wrought-iron chimney of novel design, which has recently been built at Creusot, France, is of interest. The chimney stands on a masonry foundation, extending 3 ft. 3 in. above the ground, and is an iron tube 279 ft. high, 23 ft. in diameter at the base and 7 ft. 6 in. at the top. The weight of iron is 80 tons. The shaft was built in successive rings, each 4 ft. 1 in. in height, the thickness varying from $\frac{9}{16}$ in. at the bottom to $\frac{1}{4}$ in. at the top. The nine lower rings were formed of eight plates each, the upper ones of four plates each. The base was encircled by a massive angle iron bolted to the foundation. The eight lower rings were lined with fire-brick. The erection of the chimney occupied 70 days, including taking down the flying scaffold. The latter was of a somewhat novel character. It consisted of a central wrought-iron tube 7 in. in diameter, and provided at the bottom with four wooden cross-bars or arms, so clamped that their length could be adjusted to suit the varying diameter of the chimney and carrying the internal platform. These arms rested on angle brackets refitted to the interior of the plates. The upper part of the central tube carried four cross-arms, or jibs, each consisting of a pair of timbers stiffened by raking struts from the central tube. From their outer ends was slung the exterior circular platform.

The latter consisted of a pair of angle-iron rings, to the outer part of which was riveted a plate-iron fence, while the inner was provided with T-iron stanchions. Radial bearing timbers, resting on these rings, and adjustable endwise to suit the varying diameter of the chimney, carried the platform, an annular space being left just sufficient for hoisting the plates. The latter operation was effected by a rope passing over an adjustable pulley fixed to each jib in turn, and carried down a central tube to a snatch block fixed at the bottom of the chimney. As each successive ring was riveted up, two pairs of bars were laid across, by which the scaffold was slung by four jack-screws furnished with ratchet collars, and thus raised high enough to take a bearing on the next set of angle braces. The complete scaffold weighed about four tons, and the heaviest plate about 900 lbs. The chimney cost about $8,000, not including the masonry foundation.

Blaine's Vitrified Clay Ties.

The accompanying illustration shows the vitrified clay tie devised by Mr. George E. Blaine, of Dayton, O. The cut shows the arrangement very clearly, the base or foundation consisting of a conical support of vitrified clay, as the inventor calls it, while the rails are held in place by chairs and rods, the flat chair resting on the clay base, and holding the rails by bolts and clamps.


BLAINE'S VITRIFIED CLAY TIE.

A number of these ties were put in on a side-track in the New York, Pennsylvania & Ohio yard in Dayton, O., some ten months ago. The track is constantly used for heavy switching and we are informed that at the present time "the ties appear to be in as good condition as when put in, and to hold the rail in line and surface."

Marine Engineering.

It is understood that the property of the Delaware River Shipbuilding Company, at Chester, Pa., together with the Morgan Iron Works in New York, will pass into the hands of a new concern, to be incorporated under the name of the Roach Shipbuilding & Engineering Company. The stock of this company will be largely held in London, but a portion of it will be placed

in this country. The works will be managed by an American board, with John B. Roach, George E. Reed and Henry Steers at its head. The new concern will have a capital of $1,500,000 preferred stock; $1,500,000 common stock, and $3,000,000 debenture bonds.

Manufacturing Notes.

THE contract for furnishing eight large lathes for the Government gun factory at the Washington Navy Yard has been awarded to William Sellers & Company, Philadelphia, the contract price being $416,460. With these lathes guns of the largest size can be finished.

AT the shops of William Tod & Company, Youngstown, Pa., engines are under construction for the Latrobe Steel Works, the Anniston Rolling Mill and the Pennsylvania Steel Company. A pair of large blooming mill engines are being built for the Pennsylvania Rolled Steel Wheel Company at Norristown.

THE Detroit Wheel & Foundry Company, Detroit, Mich., has a contract for iron work for the new lighthouse station at the mouth of the Mississippi.

THE Nashua Iron & Steel Company, Nashua, N. H., is making the shafting for two Government cruisers now building in Baltimore.

THE St. Louis Iron & Machine Works are building a new erecting shop 232 × 80 ft. This building will be provided with steam cranes traveling its entire length, and will have a wide gallery on either side, in which a number of machine tools will be placed.

THE new plant of the Pennsylvania Steel Company, at Sparrow's Point, near Baltimore, has now four blast furnaces in operation and work is progressing on the Bessemer steel plant and the machine shops. The steel works will have four 18-ton converters, a blooming mill and a rail mill. Work will soon be begun also on an open-hearth steel plant. Preparations are being made for constructing a large shipbuilding plant in connection with these works.

Cars.

THE works of the United States Rolling Stock Company, at Anniston, Ala., are building 200 flat cars for the Montgomery, Tuscaloosa & Memphis Railroad.

THE St. Charles Car Company, St. Charles, Mo., has completed eight baggage, two combination and 16 passenger cars for the Rio Grande Western Railroad.

THE Harlan & Hollingsworth Company, Wilmington, Del., recently completed and delivered to the Louisville & Nashville Railroad 11 first-class passenger coaches.

THE Middletown Car Works, Middletown, Pa., are building 400 iron cars, which are to go to Brazil.

THE Scarritt Furniture Company, St. Louis, is furnishing the Scarritt seats for a number of new passenger cars which the Chicago & Alton Company is now building at its Bloomington shops.

THE shops of the Mount Vernon Car Company, Mt. Vernon, Ill., are nearly completed and were to start up about August 1 on an order for 200 hopper-bottom gondolas for the Louisville & Nashville Railroad.

THE Erie Car Works, Erie, Pa., have large orders for cars for the Pennsylvania Railroad; the Union Pacific; the Missouri Pacific; the Baltimore & Ohio; the New York Central; the Columbus, Hocking Valley & Toledo, and the Cleveland, Cincinnati, Chicago & St. Louis Railroad.

THE South Baltimore Car Works have a contract for a large number of box-cars and gondolas for the Baltimore & Ohio Railroad.

THE Iron Car Company, which recently suspended payment, is to be reorganized, arrangements to that effect having been made at a meeting of the creditors and stockholders. The creditors have granted time and are to be paid in full, and it is understood that a large amount of new capital is to be put in the concern.

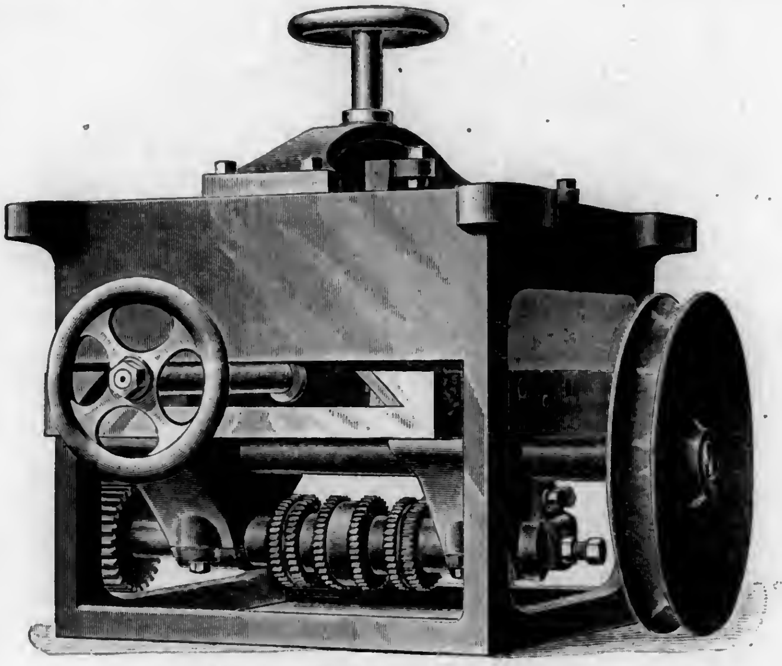
Locomotives.

THE Rogers Locomotive Works, Paterson, N. J., recently completed six heavy switching engines for the Lake Shore & Michigan Southern Railroad, and two heavy freight engines for the Birmingham Mineral Railroad in Alabama.

THE Baldwin Locomotive Works, Philadelphia, are building 25 consolidation freight engines, with Wootten fire-boxes, for the New York, Lake Erie & Western Railroad, and 25 consolidation engines, with 20 × 24-in. cylinders, for the Rio Grande Western Railroad. These works have received an order for 30 Forney engines for the Manhattan Elevated Railroad.

THE Brooks Locomotive Works, Dunkirk. N. Y., recently completed 20 ten-wheel engines for the Lake Shore & Michigan Southern Railroad. They are building 25 engines, with 18 × 24-in. cylinders, for the Illinois Central.

THE New York Locomotive Works, Rome, N. Y., are building 8 eight-wheel locomotives, with 17 × 24-in. cylinders, for the Charleston, Sumner & Northern Railroad. They are also building six passenger engines, with 18 × 24-in. cylinders, and four with 17 × 24-in. cylinders, for the Rio Grande Western Railroad.



VALVE PORT MILLING MACHINE.

THE Portland Company, Portland, Me., is building for the Maine Central Railroad four mogul passenger engines, with 19 × 26-in. cylinders, and driving wheels 65 in. in diameter.

The Davis Valve Port Milling Machine.

THE accompanying illustration shows a very convenient and useful machine for milling out ports in the valve faces of steam cylinders. It is much lighter than a cylinder of any ordinary size, and can be readily placed upon one while in position, using the stud holes for attachment. It is claimed that by it work can be duplicated exactly and in very short time.

The machine, as shown, consists of a frame that is of itself a template resting on the seat that the studs are placed in and that supports the steam-chest; this frame carries another frame, which has two distinct movements, carrying milling cutters that are arranged on a mandrel with space washers, so that the bridges and ports can be all cut to dimensions at one operation. The inner frame is fed down into the cut by the hand-wheel and screw shown on top, and is fed the length of the ports by the hand-wheel. The machine is operated by a rope belt similar to that used for driving drills.

This machine is made by the well-known firm of Pedrick & Ayer, of Philadelphia.

A Triple-Expansion Pumping Engine.

THE Risdon Iron & Locomotive Works, San Francisco, have completed a triple-expansion pumping engine on the Davidson

system for the town of Jamaica, N. Y. The steam cylinders are 9 in., 14 in. and 24 in. in diameter and 24 in. stroke; the pump is 24 in. in diameter. The intended duty is 4,000,000 gallons per day, but the pump has performed 50 per cent. more without excessive piston speed. The three cylinders are arranged in tandem fashion, but the arrangement is a somewhat unusual one, the high-pressure cylinder being in the rear; then the low-pressure and the intermediate cylinders in the front. This calls for a special arrangement of the piston rods to avoid internal packing. The high-pressure piston at the rear end is connected with the piston of the low-pressure cylinder in the middle. From the pistons of the latter there are two rods passing alongside of the intermediate cylinder, in tubes provided with packing glands next to the pump at the front. These two rods are there keyed into a crosshead on the rod connecting the intermediate and pump pistons, so that the high and low-pressure pistons are on one rod and the intermediate and pump pistons on another, the two sets being connected by the double side rods.—*Industry, San Francisco.*

OBITUARY.

EDWARD FRY, who died in Brooklyn, N. Y., June 26, was formerly Engineer in the Navy. Since 1878 he had been connected with the Brooklyn Water Works, and for several years had charge of all the pumping machinery.

CHIEF ENGINEER E. S. DE LUCE, U. S. N., died at New Brighton, N. Y., June 25, aged 62 years. He was appointed Third Assistant Engineer in 1849, promoted in 1851 and 1853, and made Chief Engineer in 1861. During the War he had charge of the Machinery Department at the Boston Navy Yard and afterward at the Brooklyn Yard. He was retired in 1879, after 30 years' service.

MAJOR-GENERAL JOHN CHARLES FREMONT, who died in New York, July 13, aged 77 years, was best known publicly from his military and political career, an account of which need hardly be given here. In early life he served for two years in the Navy and from 1838 to 1848 he was an officer in the old Corps of Topographical Engineers. In that position he made the explorations of the then unknown regions of the Rocky Mountains and the Sierra Nevada, which gave him a great reputation. General Fremont may be said to have been the first man who found a practicable railroad route to the Pacific, and he made strenuous but unsuccessful efforts to build such a road on the Southern line, which he always favored as the best.

DR. CHRISTIAN HENRY FREDERICK PETERS died suddenly at Clinton, N. Y., July 19. He was born in Germany in 1813 and graduated at the University of Berlin, after which he continued his studies at Copenhagen. In 1838 he accompanied Baron von Waltherhausen to Sicily, where until 1843 he was engaged on the survey of Mount Etna. The published results of this work are said to afford the most exhaustive description that has been given of any mountain. On the completion of this survey Dr. Peters was engaged in Naples for several years in the geodetic survey of that kingdom. At the close of the revolution of 1848 he left Italy and went to Turkey, where he continued his scientific researches. In 1853, on the recommendation of Mr. George P. Marsh, he came to America. His letters from European scientists procured for him employment in the United States Coast Survey, he being stationed first at Cambridge Observatory and later at the Dudley Observatory, Albany. In 1858 he was appointed director of the Litchfield Observatory of Hamilton College at Clinton, and a few years later was made Professor of Astronomy in the College also; he retained both positions until his death. He was considered one of the most able of modern astronomers. He was at the head of the expedition which, in 1869, observed the eclipse of the sun from the station at Des Moines, Iowa. Dr. Peters discovered more asteroids than any other astronomer. He catalogued over 75,000 zodiacal stars and recovered more than twelve thousand solar spots. He was employed by the Regents of the University of New York to determine the longitude and latitude of places in the State. His first series of celestial charts, 20 in number, published in 1882, give accurate pictures of the parts of the sky they severally covered, each marking the place of from 2,500 to 3,500 telescopic stars.

GENERAL SILAS SEYMOUR, who died in New York, July 15, aged 73 years, was one of the best known civil engineers in the country, and it was his fortune during the early months of the Civil War to render the Government timely service in organizing the military railroad service. He was born in Stillwater, N. Y. His career as an engineer began in the preliminary surveys of the New York & Erie Railroad, and he had become Engineer and Superintendent of Transportation when that road was completed as far as Dunkirk. He then built the Buffalo & New York City Railroad, now part of the Erie, and on this line was the famous Portage Bridge, probably the greatest wooden bridge ever built, 800 ft. long and 234 ft. high, over the Genesee River. The firm of Seymour, Morton & Company, which Mr. Seymour organized in 1854, now began a large and increasing business in railroad construction throughout the country. He was elected State Engineer of New York in 1855, and soon after was appointed by the United States Government to report upon the feasibility of bridging the Mississippi River at Rock Island. When the War broke out he was employed by the War Department for a time in organizing the military railroad service, and afterward served on the staff of General Daniel E. Sickles. He was appointed Chief Engineer of the Washington Aqueduct in 1863, and at this time also he built a new railroad bridge across the Potomac. In 1864 he became Consulting Engineer of the Union Pacific Railroad Company, and was engaged in the construction of that great work until its completion. From 1872 to 1878 he was in Quebec as Engineer of the North Shore Railroad, and in the latter year was chosen President of the Massachusetts Central Railroad Company. In 1880 he became Consulting Engineer of the New York, West Shore & Buffalo Railroad, and in the following year was again elected State Engineer of New York. It was during this term of service that General Seymour's views on the canals and the preservation of the timber of the Adirondacks were made prominent. Since the expiration of his term as State Engineer he has done business in New York as a consulting expert, maintaining connection with various enterprises. General Seymour's writings on subjects concerning his profession have been valuable, and occasional rather than voluminous.

PERSONALS.

DANIEL BONTECOU has been appointed Chief Engineer of the Kansas City, Fort Scott & Memphis Railroad.

A. C. HIPPEY, recently on the Pennsylvania Railroad, has been appointed General Superintendent of the Norfolk & Western Railroad.

C. A. BARTLETT is Engineer in charge of the construction of the first division of the new Winona & Southwestern Railroad in Minnesota.

F. N. FINNEY, formerly of the Wisconsin Central, is now President of the Minneapolis, St. Paul and Sault Ste. Marie Railroad Company.

A. A. MCLEOD, late General Manager, has been chosen President of the Philadelphia & Reading Railroad Company, in place of AUSTIN CORBIN, who has resigned.

EDWARD DICKINSON has been appointed General Superintendent of the Trans-Ohio lines of the Baltimore & Ohio Railroad. He has been for some time past on the Union Pacific.

S. H. HARRINGTON is now Mechanical Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Railroad. He recently held the same position on the New York, Lake Erie & Western.

E. A. WILLIAMS has been appointed Master Mechanic of the Minneapolis, St. Paul & Sault Ste. Marie Railroad, succeeding T. A. FRASER, who has accepted a position with the Wells & French Company, of Chicago.

M. D. WOODFORD has been elected President of the Cincinnati, Hamilton & Dayton Railroad Company. He was recently General Manager, and has served on the Erie, the Michigan Central and the Wheeling & Lake Erie.

JOHN MCLEOD has been appointed General Manager of Construction of the Richmond, Irvine & Beattyville Railroad, a line about 100 miles long in Kentucky. He has also charge of the building of the New Albany Belt Railroad.

JOHN W. CLOUD is now Western Representative of the Westinghouse Air Brake Company, with office at 974 Rookery Building, Chicago. R. A. PARKE is Eastern Representative of the same Company, with office at 160 Broadway, New York.

MAJOR J. C. PAUL, late General Manager of the Woodruff Sleeping Car Company, and Superintendent of Equipment of the Pullman Company, has been appointed Vice-President of the American Steel Car Wheel Company, with office in New York.

F. T. HATCH has been appointed Engineer of Maintenance of Way on the Pittsburgh, Cincinnati & St. Louis, succeeding GEORGE W. KITTRIDGE, who recently left that position to become Assistant Chief Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Railroad.

CHARLES PAINE, late of Pittsburgh, has established an office in New York, with his two sons as partners, the firm name being Charles Paine & Company. The new firm will act as consulting engineers for railroad and other work. Mr. Paine's long experience and high reputation as an engineer make all comment unnecessary.

PROFESSOR JOHN SMOCK has been appointed State Geologist of New Jersey, to succeed Professor George H. Cook, deceased. Professor Smock has been for some time at the head of the Museum of Natural History at Albany, N. Y., but was formerly for several years employed as Assistant to Professor Cook on the New Jersey survey.

EDWARD W. KINSLEY has been reappointed a member of the Massachusetts Railroad Commission for another term. He has been on the Commission for 11 years, having been first appointed in 1878, and having served continuously since that time, with the exception of one year. Mr. Kinsley has been an active member of the board and has practical knowledge of railroad work and an acquaintance with railroad problems which have made him a very useful one.

PROFESSOR JAMES RUSSELL SOLEY has been appointed Assistant Secretary of the Navy, a new office, just created by law. He is a Massachusetts man, graduated from Harvard College in 1870 and was soon afterward appointed Assistant Professor in the Naval Academy at Annapolis. In 1873 he was made Professor; in 1878 he was sent on special duty to the Paris Exposition of that year, and in 1882 he was transferred to Washington, where he has since been in charge of the Library of the Navy Department, and of all its publications.

PROCEEDINGS OF SOCIETIES.

Master Car Builders' Association.—The office of John W. Cloud, Secretary, has been moved from Buffalo to Chicago. His address is now 974 Rookery, Chicago, Ill.

Institution of Civil Engineers of Japan.—A special meeting or convention, lasting for a week, was recently held at the Imperial College of Engineering near Tokio, Japan, to celebrate the 10th anniversary of the foundation of this Society. The programme included a business meeting, the reading of papers on different subjects, a banquet and visits to a number of public works, including the Shinbashi Railroad Works; the Fukugawa Copper Works; the Ishikawa Gima Docks; the Kanegafuchi Cotton Mills and other establishments.

A large number of members and invited guests were present at the meeting, in which much interest was taken. The Society originally included only graduates of the Imperial University, but all engineers engaged in civil, mechanical, electrical work, naval construction and architecture are now admitted. There are over 1,000 members in the Society.

The officers are: President, Yamao Yozo; Vice-President, Watanabe Hiromoto; Secretaries, M. Shimudza and M. Matsuo. The President was recently Minister of Public Works and the Vice-President is President of the Imperial University.

American Society of Civil Engineers.—The Annual Convention began at the Mountain House, Cresson, Pa., June 26. Mr. William Metcalf was elected Chairman, and the customary routine business was gone through with. At the first session papers were read on the Oakley Arch, by Mr. J. Foster Crowell; on Cross Sections in Deep Rock Cuts, by F. W. Watkins; on Stresses in Elastic Systems, by William Kane, and on the Temperature of Water, by Desmond Fitzgerald. All of these papers were discussed.

At the session of the second day papers were read and discussed on Comparative Tests of an Electric Motor and the Steam Locomotive on the Manhattan Elevated Road, by Lincoln Moss; on Irrigation in India, by H. M. Wilson; on the Cheapest Railroad in the World, by Arthur Pou, and on Permanent Effects of Strains in Metals, by Professor R H. Thurston.

At the evening session President W. P. Shinn delivered his annual address, which was a summary of the progress of engineering during the past year. Mr. R. B. Stanton then gave a description of the great Cañon of the Colorado.

On the third day, Friday, in the morning there was an excursion to Johnstown, in which most of the members joined. A session was held in the afternoon, at which a number of papers were read and discussed. In the evening the annual banquet was held.

On the fourth day, Saturday, an excursion was made in the morning over the Bell's Gap Railroad; in the afternoon a business session was held, at which reports of progress were received from the standing committees. A communication from the Western Society of Engineers on an International Engineering Congress was presented, and the President was authorized to appoint a committee to consider the subject and meet with other committees. The usual nominating committee was appointed. In the evening the members were taken by a special train to Altoona to attend a reception given in their honor by Mr. and Mrs. Theodore N. Ely.

At the Monday morning session a number of papers were read, including one on the Litoral Movements of the New Jersey Coast, by L. M. Haupt; Electric Railroads of Nashville, by O. H. Landreth; Ventilation of Tunnels, by N. W. Eayres; the Silverton Railroad, by C. A. Gibbs; the South Park Dam, by A. N. Snyder; Break in the Champlain Canal, by Secretary Bogart. A number of other papers were read by title.

The meeting concluded in the afternoon by a visit to the great shops at Altoona, to which members were carried by special train.

International Association of Car Accountants.—The Annual Convention was held in New York, beginning June 24. The following officers were elected for the ensuing year: President, E. M. Horton, Illinois Central; Vice-President, C. H. Ewings, New York Central; Secretary, S. P. Sechrist, Cleveland, Ohio; Treasurer, M. C. Traut, Toledo & Ohio Central; Executive Committee, A. Hale, C. J. Fellows and C. P. Chesebro.

Reports were presented by the various committees; those on Cypher Code, Demurrage and Per Diem Car Service received special attention and called out long discussions.

A number of papers were presented, including Errors and their Correction, by A. Hale; Straight per Diem, by M. C. Traut; Detention of Foreign Cars, by A. D. Penfold; Decreasing Mileage of Cars, by W. G. Wattson; Economical Working of the Car Record Department, by Edmond Yardley.

It was decided to hold the next meeting at Denver, Col. Besides the business of the Convention, which lasted three days, the members were entertained by a trip to West Point and return, and an excursion to Long Branch and Ocean Grove.

American Boiler Makers' Association.—The annual meeting began in New York, July 1. It was opened by a short address from the President. At the first session reports were presented by Committees on Manholes; on Materials and Tests; on State Inspection Laws; and on Riveting and Calking, all containing matter of much interest. The Convention remained in session for three days, discussing a number of practical questions, including the subjects mentioned above, and also Raising the Standard of Work and Workmen; Boiler Insurance; Safety Valves and Horse-Power. Particular attention was paid to the subject of State Inspection Laws.

The following officers were elected for the ensuing year: President, James Lappan, Pittsburgh. Vice-Presidents, Philip Rohan, St. Louis; John Mohr, Chicago; Christopher Cunningham, Brooklyn. Secretary, A. T. Douthett, Allegheny, Pa. Treasurer, R. Hammond, Buffalo, N. Y. During the Convention the members visited the Brooklyn Navy Yard, took an excursion around the Harbor, and visited several New York establishments.

Association of Railroad Telegraph Superintendents.—The ninth annual meeting was held at Niagara Falls, June 18 and 19. The following officers were elected: President, George T. Williams, Cleveland, Ohio; Vice-President, George M. Dugan, Jackson, Tenn.; Secretary and Treasurer, P. W. Drew, Chicago.

A number of papers of much interest were read, including one on the Development of the Block System, by Robert Stewart; Special Lighting at Wrecks, by W. F. Taylor: Electric Lighting in Railroad Service, by B. Leonard; Train Dispatching, by George C. Kinsman; Correct Time, by Professor H. S. Pritchett, and the Ries System for Increasing Adhesion, by Charles Selden. These papers and a number of other subjects were discussed.

It was resolved to meet next year in Cincinnati. A number of new members were elected.

Boston Society of Civil Engineers.—At the regular meeting, June 19, Francis Blake, Frank P. Johnson, George H.

Nye, and George C. Stoddard were chosen members; Edward P. Fisk, an associate member.

The subject for the meeting was the Treatment of Sewage, and three papers were read: The Purification of Sewage by Filtration and Chemical Precipitation, by Hiram Mills of the State Board of Health; the Sewage Disposal Works at Worcester, by Charles A. Allen, City Engineer; Treatment of Sewage at Winchester, by W. F. Learned, Assistant Engineer of the Boston Water Works. The several papers were fully discussed.

Civil Engineers' Club of Cleveland.—At the regular meeting, July 8, James Morris Wright was chosen a member. The Committee on Affiliation reported that nothing was accomplished at the Conference in New York. Notice was received that the Iron & Steel Association of Great Britain will not visit Cleveland as a body. The first and second proposed amendments to the Constitution of the Association of Engineering Societies were discussed and adopted.

Mr. C. O. Arey read a paper on Methods of Wall Decoration. After noting the objections to oil-colors and the kalsomining process, he narrated his experience with other methods. The encaustic process, as practised by the ancient Greeks, was found too expensive. The fresco practised by the early Renaissance was found satisfactory, with the exception that the work was liable to be injured or broken after completion, by the finishing carpenters. He then tried many experiments to find a method similar to this fresco which could be applied on a dry wall, this was accomplished by a chemical union of alum and lime, providing only mineral colors were used. This method allows one to apply on the wall a permanent finish, unaffected by water, at a very moderate expense. The paper was discussed by Messrs. Barber, Hermann, Richardson, Porter and others.

After adjournment the members visited the electric light mast which was wrecked by the storm a short time before.

Engineers' Club of Cincinnati.—At the regular July meeting Alfred Allen Stuart, Resident Engineer of the Central Railway & Bridge Company, Newport, Ky., was elected to membership.

It was decided not to adjourn during the months of July and August.

The paper for the evening was by Mr. Ernst Lietze under the title of Distribution of Power from a Central Station, in which he gave an exhaustive resumé of the various methods of transmitting power for mechanical purposes, and a comparison of the results derived from each. He also presented numerous formulæ and calculations and tables deduced from them showing the specific duties, efficiencies, etc., for the various systems. The second part of the paper comprised a detailed description of the Pneumatic Power Supply of the *City of Paris.*

Engineering Association of the Southwest.—At the regular meeting in Nashville, Tenn., July 10, a Committee was appointed to represent the Association at the Road Congress, which will meet in Nashville, August 26.

An address on Captain James B. Eads, prepared by Mr. E. L. Corthell, was read, and the Association was requested to contribute to the monument to be erected to Captain Eads in St. Louis.

A Committee was appointed to make arrangements for the visit of the Iron & Steel Association of Great Britain, which, under the present programme, will reach Nashville, October 15, and will go from that place to Knoxville, Birmingham, Anniston and other places farther South.

It was resolved to appoint a Committee of three to draft a bill to be presented to the next Legislature to remove the tax at present levied on engineers and architects. There was some discussion showing the injustice of such taxes, while members of other professions are free from the burden.

Western Society of Engineers.—At the regular June meeting in Chicago action was taken on a report presented by the Committee on an International Engineering Congress. It is proposed to hold this Congress in Chicago at the time of the World's Fair, and to invite engineering societies in other countries to send delegates. A committee was appointed and communications sent to the American Society of Civil Engineers and other societies.

Engineers' Club of Minneapolis.—At the regular meeting in June Professor W. A. Pike was appointed to represent the Club at the convention of the American Society of Civil Engineers at Cresson.

Mr. Walter S. Pardee read a paper on the Ventilation of School Buildings, which was illustrated by numerous diagrams. This paper was discussed by the members present.

Engineers' Club of St. Louis.—At the regular meeting, June 18, a special committee was appointed to consider amendments to the agreement of the Association of Engineering Societies.

The Secretary read a paper on River Pollution in the United States, by Professor Charles C. Brown, in which the subject was divided into three heads: First, streams used for water-supply only; second, streams used for drainage purposes only; third, streams used for both water-supply and drainage. The paper was confined principally to the consideration of the latter class, it being the most important. The author gave abstracts of the work done in different States heretofore, in the direction of investigating the pollution of streams, accompanying his remarks by tables showing the results of chemical analysis of a large number of different waters. The author said he would be glad to receive further data, and asked for criticism and discussion of the subject. The paper was briefly discussed by members present.

Engineers' Club of Kansas City.—At the regular meeting, June 9, the President tendered his resignation, but was requested to withdraw it.

The meeting was taken up by a general discussion on the subject of Gas Engines, in which nearly all the members present joined.

Technical Society of the Pacific Coast.—At the regular June meeting in San Francisco four new members were elected. Mr. C. D. Hervey exhibited some new water pipe fittings. Arrangements were made for examining electrical apparatus and an electric light plant

Professor Irving Stringham read a paper on Napier's Definition of a Logarithm, and its Consequences. This was generally discussed by members present.

NOTES AND NEWS.

Wet and Dry Steam.—The researches of Professor Denton, of the Stevens Institute, Hoboken, N. J., have proved that when a steam jet is discharging freely into air from a nozzle, if a gap is observable between the visible cloud and the nozzle, then the steam is practically dry, and may also be considered practically dry even if the vapor is very faintly visible; but immediately it becomes distinctly white the water present has risen to from 1 to 2 per cent. These facts are most valuable in making rapid tests as to relative dryness, and the test is unexpectedly delicate. We were all in the habit of considering steam drier the more blue the appearance of the jet, but we were unaware of the accuracy of the test.

Case Hardening in America.—A writer in the London *Engineer*, commenting on the reversing levers in use on American locomotives, says: "The pins are not large enough, and the case hardening is rarely first-class. It is done in a very primitive manner, and it is seldom, indeed, that a well-designed case-hardening plant is met with. It is an art which does not receive in America the attention its great value so justly merits."

The Nicaragua Canal.—The directors chosen at the recent annual meeting of the Nicaragua Canal Construction Company are: Warner Miller, A. C. Cheney, Alfred M. Hoyt, W. L. Scott, J. F. O'Shaughnessy, J. W. Miller, R. A. Lancaster, J. L. Macauley, N. K. Fairbanks, Smith M. Weed, Henry R. Hoyt, Robert Sturgis, Edward Holbrook. The board elected the following officers: President, Warner Miller; Vice-President, A. C. Cheney; Secretary, J. W. Miller; Treasurer, Henry R. Hoyt.

The accounts of progress from the line of the canal continue to be very good.

The New Hatteras Lighthouse.—The bids for the construction of the new lighthouse on the Outer Diamond Shoal, off Cape Hatteras, were opened at the office of the Lighthouse Board in Washington, July 1. Some description of this lighthouse has already been published in our columns. It will be a work involving some time and trouble, on account of the difficulty of making the foundations. Four bids were received, as follows: Theodore Cooper & Company, New York, $474,000, work to be completed by January 1, 1893; Anderson & Barr, Jersey City, $485,000, to be completed January 1, 1892; Will-

iam Sooy Smith, Chicago, $488.325, to be completed in three years; James Andrews and Gustav Lindenthal, Pittsburgh, $1,820,300. to be completed in two years. Taking time into account, the bid of Anderson & Barr may be considered the lowest. All the bidders have had much experience in difficult foundation working, and the firms of Anderson & Barr and William Sooy Smith are constantly engaged in such work.

The remarkable thing about the bids is that three of them should be so close together, while the fourth is for nearly four times the amount of the lower bids. It must be remembered that this will be, as stated above, a very difficult piece of work, on account of the shifting and uncertain nature of the shoal upon which the lighthouse is to stand, and also of the fact that the work must be done practically at sea, and on that stormy coast the time is very uncertain, as it will be possible to work only in very fine weather.

Railroads of Europe.—The following table gives the total length of railroad lines in operation in Europe on January 1, 1889, the latest date to which official figures are attainable. The figures are given by *les Annales des Ponts et Chaussées.* The first column gives the length of railroad in miles; the second the length of railroad, in miles, opened in 1888, and the third the per cent. of increase during that year.

RAILROADS OF EUROPE.

	Country.	Mileage, January 1, 1889.	Increase in 1888. Miles.	Increase in 1888. Per cent.
1	Germany	25,213	608	2.5
2	France	21,912	644	3.0
3	Great Britain and Ireland	19,918	221	1.1
4	Russia	18,278	557	3.1
5	Austria-Hungary	15,989	637	4.0
6	Italy	7,675	473	6 6
7	Spain	6,008	110	1.9
8	Sweden and Norway	5,648	86	1.6
9	Belgium	3,000	91	3.1
10	Holland	1,864	30	1.6
11	Switzerland	1,735	43	2.5
12	Roumania	1,538	77	5.3
13	Denmark	1,224	....	....
14	Portugal	1,189	52	3.6
15	Turkey and Bulgaria	1,024	159	18.3
16	Greece	388	13	3.3
17	Servia	321	....	...
18	Island of Malta	7	....	...
	Total	132,931	3,801	2.9

The countries are arranged in the order of their mileage. Only railroads actually in Europe are included; the lines extending into Asia—Russian Transcaspian, etc.—are omitted.

A Long Bridge.—One of the largest bridges at present proposed in the United States is to be built across the Columbia River at Vancouver, Wash., some 12 miles north of Portland, Ore. The bridge proposed is a low bridge with a long draw-span. Its length will be 3,600 ft., not including the approaches. At the point chosen for the bridge the Columbia River has a depth of about 25 ft. at low-water, the river being very wide and comparatively shallow.

The Forth & Clyde Canal.—Surveys have been completed for the proposed new canal across Scotland, which is to connect the Clyde River with the Forth, and to furnish a passage for ships across Scotland. The line proposed follows the valley of the Forth to Loch Lomond, near its southern end. From this point three lines to the sea are practicable: Through Loch Lomond to Loch Tarbet, and thence to Loch Long, which communicates directly with the ocean. The second is from Loch Lomond, through the Vale of Leven to the Clyde at Dumbarton and the third from Loch Lomond by a cut of about four miles in length to the Clyde at another point. If the canal is to serve ocean-going vessels chiefly, it is considered that the first line is the best. The total length of the canal from the point where it leads the Forth to Loch Lomond would be 38½ miles, but near the western end a tunnel 2¼ miles in length would be required. The cutting west of Loch Lomond would depend upon the line adopted, varying from 1¾ miles by the first line to 5½ miles by the second. It is proposed to make the canal throughout with a depth of 30 ft. of water and a width of 72 ft. at the bottom, the side slopes depending upon the nature of the ground. The locks would be large enough for vessels of the largest size. The cost is estimated at somewhere about $40,000,000, and it is expected that a very large traffic would pass through the canal, as there would be a great saving in distance for all shipping bound from the Clyde and from points on the west coast of England to points on the east coast of England and Scotland, and ports on the Continent. Moreover, the passage around the north of Scotland is a very dangerous one in bad weather, and there would be a considerable saving in safety as well as in distance. Abundant supply of water for the canal could be obtained from Loch Lomond, which has a large area, and contains a great body of water.

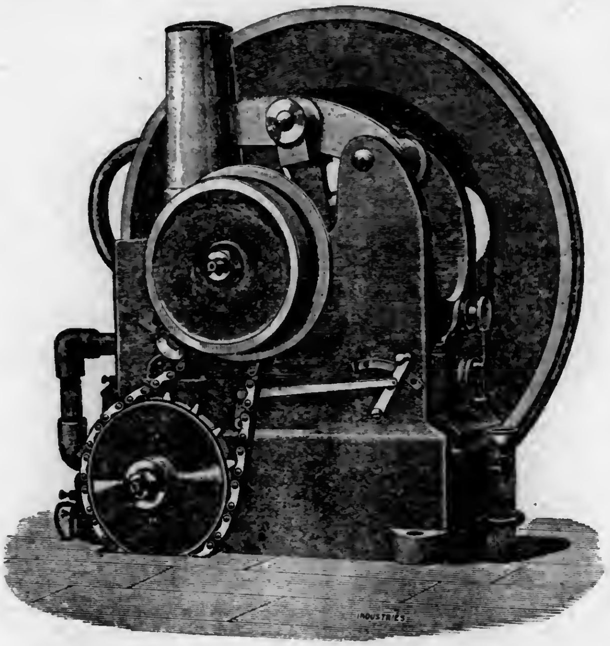
Large Railroad Systems.—In an elaborate article on the process of consolidation of our railroads into large systems, the *Commercial and Financial Chronicle* says: "The most striking results, however, are reached in summarizing the figures detailed above. Treating the Chicago & Northwestern and the various Vanderbilt lines east of Chicago as one interest, and treating the Gould and Huntington lines in the same way, we find that sixteen leading interests and corporations control 111,149 miles of road. If we take out the 10,867 miles in the Canadian Pacific and the Grand Trunk systems, over 100,000 miles of road would remain controlled or directed by only 14 interests and corporations. That is, about two-thirds of the entire mileage of the country is controlled by these 14 interests. The order of the interests is:

	Miles.
Vanderbilt lines, including Chicago & Northwestern	15,663
Gould lines, including Wabash, but not Central Branch U. P.	11,879
Huntington lines, east and west of Mississippi	9,038
Atchison and St. Louis & San Francisco	8,965
Union Pacific	8,047
Pennsylvania	7,664
Richmond Terminal	7,469
Chicago, Burlington & Quincy	6 883
Canadian Pacific	6,766
Chicago, Milwaukee & St. Paul	5,678
Chicago, Rock Island & Pacific	4,587
Northern Pacific and Wisconsin Central	4,429
Grand Trunk	4,101
Louisville & Nashville	3,827
Great Northern	3,278
Illinois Central	2,875
Total 16 interests and systems	111,149
Less Canadian Pacific and Grand Trunk	10,867
Total 14 interests in the United States	100,282

"Evidently under this process the work of our Interstate Commerce Commission is being greatly simplified. Evidently also, under the same process, many of the difficulties in the way of reconciling diverse and conflicting elements are being removed, thus bettering the general railroad situation and improving the outlook for railroad properties."

A Domestic Petroleum Engine.—The use of gas and petroleum engines is much more common in England than here, and many convenient forms have consequently been devised in that country. The accompanying illustration, from *Industries,* shows a little engine for house purposes, invented by Edward Butler, of Greenwich, England. This motor is very compact and is entirely self-contained. It stands on a base 12 in. long by 7 in. broad, and measures 16 in. to the top of the fly-wheel; these dimensions are smaller than those of any other gas engine in the market. It runs at 1,200 revolutions per minute without load, and at from 250 to 800 revolutions when doing work. The power developed is one-fifth of a horse-power. The explosive mixture is formed of the vapor of benzolene, together with a certain proportion of air. The cylinder is vertical and single-acting, and is 2 in. diameter by 3½ in. stroke. The piston is of the trunk type, with one end of the connecting rod attached to it. The upper end of the connecting-rod works a vibrating lever, which transmits motion by a second connecting-rod to the crank-shaft. The fly-wheel is at the back end of the crank-shaft, and the driving-wheel is at the front end. The fixed centers of the vibrating lever are on the same casting as the bed-plate. The lower part of the bed-plate forms a small reservoir for the benzolene, and this small receptacle is connected with the main reservoir, which is placed in any convenient position, by a pipe about ¼ in. in diameter. In the present case about a quart is the capacity of the larger reservoir. From the small reservoir the benzolene is drawn up by a pipe about $\frac{1}{16}$ in. diameter, and the air, which is passed through a small

inspirator, mixes with it and converts it into an explosive mixture. The explosions take place at the bottom of the cylinder once in every two revolutions. The supply of vapor is controlled by a rotating plug valve with suitable inlets and ontlets; this valve runs at one-fourth the speed of the crank-shaft, to which it is geared by an Evart's chain. Igniting sparks are ob-



tained by a current from a bichromate battery with carbon and zinc elements, and the current is transformed by an induction coil into one of higher pressure. Contact is made twice in every revolution of the valve, and as the valve only rotates at one-fourth of the speed of the crank-shaft, this is equivalent to one explosion in every two strokes of the piston. A small water-tank placed at a higher level provides the means for keeping the cylinder cool by circulating water around it. A tiny throttle-valve regulates the speed of the motor. An opening of $\frac{1}{100}$ in. in the valve is quite sufficient for the working of the motor, one-eighth of a turn on a screw with 50 threads to the inch giving this opening. It is stated that the amount of benzolene used is from $\frac{1}{2}$ pint to $\frac{3}{4}$ pint per hour. The motor can be fixed on a kitchen table, shop counter, bench, or floor, and the small water tank on a shelf or bracket, while the battery, as in the case of house bells, may be conveniently placed in a cupboard or cellar. The motor is started by giving it a few turns by hand, after which it runs without further trouble.

Tests of the Iron of the Kieff Bridge.—In the summer of 1888 Professor Belelubsky was commissioned by the Russian Public Works Department to examine and report upon the condition of the Kieff suspension bridge, then about 40 years old, and particularly to examine the quality of the wrought iron used in its construction. Fortunately a certain number of spare links, which are 12 in. broad, 1 in. thick, and about 12 ft. long, had been preserved in the storehouse adjoining the bridge, so that it was possible to replace one of the original links by a new one, and to compare it with another unused one. Four test-pieces 1 in. by $1\frac{1}{8}$ in. and 8 in. long were taken out of each link in the direction of the length, and one 4-in. piece transversely. The results were as follows:

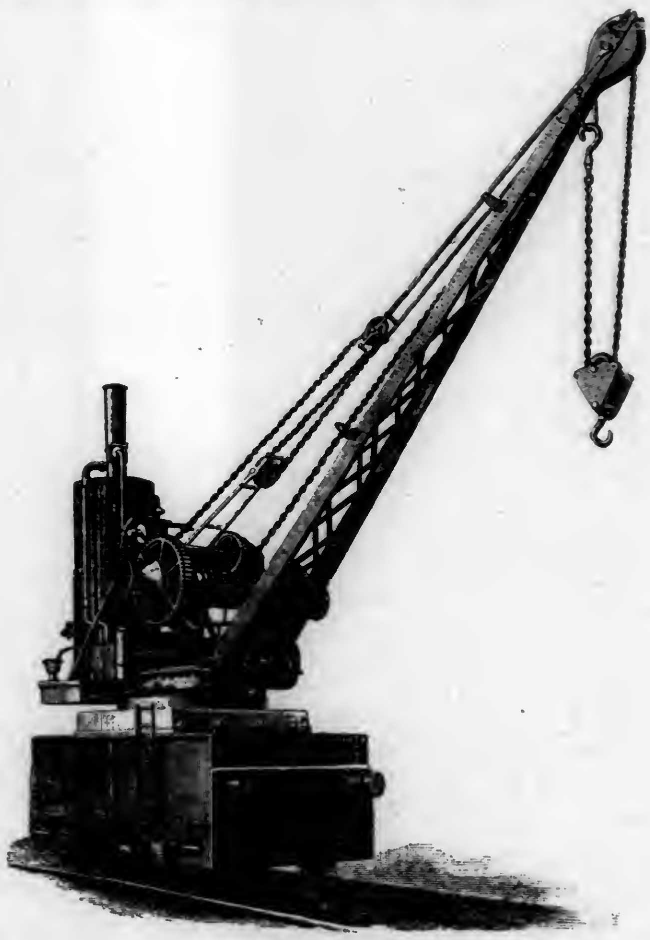
	Tensile Strength.	Elastic Limit.	Elongation.	Contraction.
	Tons.	Tons.	Per cent.	Per cent.
Link taken out of bridge—				
Mean of four longitudinal tests..	21.8	11.1	14.05	17.35
One transverse test........	14.9	..	2.10	1.60
New link from store-house—				
Mean of four longitudinal tests.	22.2	11.93	13.42	18.75
One transverse test.......... ..	17.32	..	6.00	6.80

The longitudinal tests show that the strength of the metal is substantially unchanged, in which respect they confirm the previous observations made by Professor Bauschinger, at Munich, upon the iron of old bridges. The Author recommends that in all new bridges provision should be made for comparative tests of the strength of the metal at long intervals by preserving some spare bars from the original construction.—*Stahl und Eisen.*

A Locomotive Steam Crane.—The accompanying illustration, from the London *Engineer*, shows a very compact locomotive crane, built by Mr. T. Smith, Bodley, England. This crane can lift 7 tons at 12 ft. and 4 tons at a radius of 20 ft. from the central pillar. It is mounted on a car or frame of wrought-iron plates and angles, carried on two steel axles, the wheels being set to 4 ft. $8\frac{1}{2}$ in. gauge. The wrought-iron central pillar is turned to fit true in the base-plate, which is securely fixed in the frame. The jib is of wrought-iron plates and angles, and carries the necessary chain-wheels, shafts and gearing.

The hoisting motion is by double purchase spur gearing, controlled by clutch and lever, and is provided with a friction brake controlled by a foot lever. The jib-adjusting motion is by spur and worm wheels, geared up from the engine shaft, and controlled by a clutch and lever. The revolving motion is by spur and miter wheels, geared up from the engine shaft to the main internal wheel on the frame, worked by a double friction cone, so that the movement can be stopped or reversed without stopping the engine; it is controlled by a screw lever and light hand-wheel. The propelling motion is by gearing from the engine shaft to the traveling axles, and is controlled by a clutch and lever.

The engine has two cylinders, $7\frac{1}{2}$ in. in diameter by 12 in. stroke, the valves being worked by a link motion. The boiler



is vertical, 3 ft. 9 in. in diameter and 8 ft. 6 in. high, and is provided with feed-pump and other appliances. Water is carried in a tank in the frame.

This crane is especially intended for ship-building work, but can be used for loading and other purposes as well.

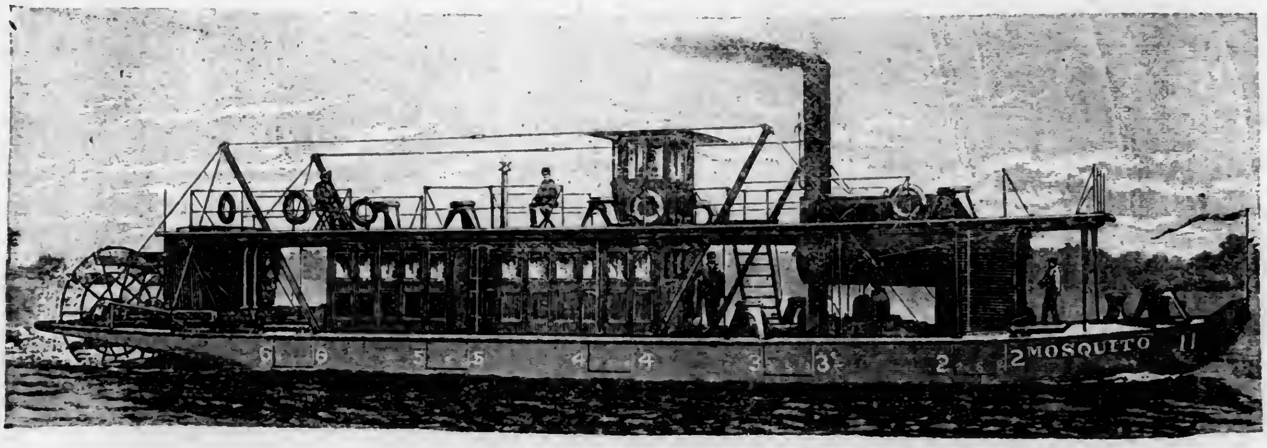
Water Works in Japan.—At the recent meeting of the Institution of Civil Engineers, Mr. J. H. T. Turner read a paper on the works for the water supply of Yokohama, which were completed in October, 1887. This was the first undertaking of the kind in Japan. Its inception was largely due to the recognition by the Japanese Government of the close relation subsisting between the use of polluted water and the development of choleraic epidemics at Yokohama. The principal original

features of the works were that they were constructed in a country subject to earthquakes, and to meet the peculiar requirements of a Japanese population. The source of supply was the river Sagami, which was tapped at a point about 28 miles distant from Yokohama. The water was raised from the river by steam-pumps, and was delivered into a depositing tank built on the mountain side. It passed from this tank through a gauge-plate into the aqueduct, and flowed by gravitation to the town. The upper portion of the aqueduct was composed of alternate lengths of 18-in. cast-iron main-pipe and masonry conduit, constructed along the precipitous rock wall of the Sagami cañon. The hydraulic gradient of the first 18 miles of the aqueduct was 6 ft. per mile, and of the last 9 miles, 14 ft. per mile, the diameter of the main-pipe being reduced to $15\frac{1}{2}$ in. Lead joints were employed everywhere except at the river crossings, where flange joints were adopted. The main-pipe delivered the water to the filter-beds and service-reservoir, which were situated at Yokohama, about one mile from the center of the town. The filter-beds were three in number, two being ordinarily in use together; they were built of concrete. The filtering material consisted essentially of a depth of 2 ft. 6 in. of sharp sand, supported in the usual way upon gravel, and underlaid by brick drains. The service-reservoir was a concrete structure, the walls being faced with brickwork. The depth of water was 18 ft. Both the reservoir and the filter-beds, and all wells and tanks, were built upon and entirely surrounded by good puddle up to the water-line—a feature of construction to which the water-tightness of all these structures was doubtless largely due, and which might be regarded as almost essential in earthquake countries. A system of by-passes permitted of the water being delivered direct to the town, without passing through either the reservoir or the filter-beds, if it was necessary to do so at any time. The distribution in the town was effected by a ramification of 4-in. and 8-in. pipes branching off an 18-in. main-pipe from the service-reservoir. The service was constant. Stand-pipes were largely used for the supply of the native portion of the town, and lead service pipes were introduced into the houses of the foreign settlement. Fire hydrants were provided in large numbers throughout the town. The entire town was placed under the control of the waste-water meter system for preventing waste of water. Water was sold by measure to manufactories and shipping, the town being rated for all domestic supply.

Excavating in Quicksand.—At a recent meeting of the New England Water-Works Association, Mr. Albert F. Noyes read the following note:

"Some years ago I had occasion to make an excavation in material known as quicksand, some 15 ft. deep, near buildings. If the excavations were made in the ordinary way, a settlement of the foundations would be likely to occur, so I adopted the following method, which in my case proved successful; and I see no reason why, under similar conditions, and in a great many cases, it could not be used to advantage. The excavation, as I have said, was about 15 ft. deep, about 60 ft. in length, and 8 ft. wide. Usually below these veins of quicksand there are veins of a coarse material which form ready conductors for the water, and the vertical distance through the quicksand is usually less than the horizontal distance; the ground water has the least resistance in the vertical direction, and tends to soften and take up the quicksand with it. If the water is drawn out, or the water level lowered below the bottom of the trench, this fine material becomes compact, very much like clay, and excavations can be easily made with perfect safety and the use of a light sheeting. In the case I refer to I used 14 pipes $1\frac{1}{2}$ in. in diameter, and these were driven equidistant about the excavation to be made, with the ordinary perforated well point, having attached outside a fine-mesh brass screen. They were driven into a stratum of coarse material from 35 to 50 ft. below the surface of the ground. The pipes were ganged together and attached to a common plunger pump, and the water was drawn down. I might state that the normal level of the ground water was within some 3 or 4 ft. of the surface of the ground, so we had to draw the ground water down some 10 or 11 ft. We found by test tubes outside of the gang that we could readily hold the water to a level, which insured the excavations being made without any difficulty whatever; in fact, the banks were dry, and the lower portion of the excavation was very firm. In this case the well points, after we used them, were sold to other parties at nearly the first cost. The pipes, which were taken from the stock at the pipe-yard, were returned and used over again, so that there was little loss in that way; and the whole cost of driving the pipe was about $18, so that the expense of that method was really less than sinking a well outside of the excavation in the usual manner."

A River Gunboat.—The accompanying illustration, from the London *Engineering*, shows a light-draft gunboat built by Yarrow & Company, Poplar, England, for service on the Zambesi River in Africa. The *Mosquito*, as the boat is named, recalls some of the boats prepared for river service during our own war.



The dimensions of this boat are: Length over all, 89 ft.; length of hull, 77 ft.; beam, 18 ft.; depth, molded, 4 ft.; draft in working trim, 1 ft. 6 in. The boat can run 10 miles an hour, which is as high a speed as is at all practicable when navigating a very shallow river, the channel of which is not known, and where there are no pilots. The boiler, which is placed forward, is of the locomotive type, and is adapted for burning wood, which is the only fuel obtainable up the rivers in East Africa. The weight of this boiler at the bow is balanced by the wheel and horizontal engines aft, which are of very simple construction. On the main deck are cabins and sleeping accommodation for the chief officer, three petty officers, and eight men, who will form the European crew, in addition to which hammocks will be swung from the upper deck for the accommodation of natives. On the top of the upper deck is placed the pilot tower, from which the steersman can obtain an all-round view.

The boat is built in floatable sections, each section being really a pontoon or tank, and of such a size as to render it easy of shipment in a ship's hold. On arriving at the destination each section will be lowered into the water, and then connected together by means of suitable straps and bolts, thus making the hull complete, after which the machinery and woodwork will be put on board.

The stern wheel is driven by two non-condensing horizontal engines, with cylinders $10\frac{1}{2}$ in. in diameter and 30 in. stroke. The boiler is of the locomotive type, burning wood, and made to work at 140 lbs. pressure. The boat carries four 3-pounder Hotchkiss guns and six Nordenfelt machine guns.

Heavy Cables.—Among the heavy wire cables recently placed on the street car lines in San Francisco are one for the Castro Street line $1\frac{5}{16}$ in. diameter, 23,000 ft. long, and weighing 64,600 lbs.; one for the Market Street line 24 600 ft. long, weighing 64,555 lbs., and one for the Piedmont line 20,800 ft. long weighing 52,710 lbs. These cables were made in Trenton, N. J., at the Roebling Works.

THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

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NEW YORK, SEPTEMBER, 1890.

THE embarkation of the body of Captain John Ericsson on board the *Baltimore*, for its final voyage to Sweden, on August 23, was made the occasion of considerable ceremony. The remains were accompanied from their temporary resting-place at the Old Marble Cemetery on Second Street, in New York, by a procession including a body of marines, a regiment of State militia, delegations from the American Society of Civil Engineers, the American Society of Mechanical Engineers, the Marine Society of the Port of New York, several posts of the Grand Army, the Swedish Society, and other public bodies. From the Battery they were conveyed to the *Baltimore* by the steam-tug *Nina*, and a number of other vessels were at anchor in the stream. A salute was fired from the old monitor *Nantucket*. The *Baltimore* at once started on her voyage, being accompanied down the Bay by a number of vessels.

As has been before remarked, such honors are very seldom paid to one who in his lifetime held no official position, but in this case they seem to be only a fitting recognition of the great services which Captain Ericsson rendered to this country, and, it may be said, to the world in general.

ONE of the most fatal railroad accidents reported for several years happened August 19, on the Old Colony Railroad, and, singularly enough, within a very short distance of the place where the great Wollaston accident took place 12 years ago. The train was an express, having seven cars, and was running at a high rate of speed when the engine left the track and turned over on its side down a low embankment. The tender and three cars also left the track, but remained on the road-bed and were not seriously damaged, but when the fourth car left the track the trucks were displaced and tore up the floor of the car, which then upset upon its side. The three rear cars remained upon the track.

With the exception of the fireman, who was caught under the engine and killed and two other trainmen who were slightly hurt, all the casualties occurred in this fourth car, and nearly every person in it was either killed or injured. There were some 50 persons in the car, and of these 11 were instantly killed, nine fatally hurt, and 18 seriously injured, some 10 or 12 more being slightly hurt. Had this car withstood the shock it seems as if the results would not have been serious, but its breaking up was the cause directly of all the injuries to passengers.

The accident will be carefully investigated by the Massachusetts Commission. The derailment was caused by a track-jack, which was left on the track by some section-men, in their haste to get out of the way of the approaching train.

THE latest report of the blast furnaces, as given by the *American Manufacturer*, shows a falling off in iron production. On August 1 there were in blast 321 furnaces, with a weekly capacity of 164,067 tons, as compared with 340 furnaces of 181,953 tons capacity on July 1. This shows a decrease in capacity of 16,886 tons, or 9½ per cent. The reduction is chiefly due to the stoppage of several large furnaces for repairs, and the usual summer slacking down. As compared with a year ago the statement shows an increase in the number of furnaces of 54, and in weekly capacity of 24,645 tons, or 18 per cent. The demand for pig iron continues good, and no increase in stocks unsold is reported.

THE furnishing of light and power from a central electric station on a very large scale is to be tried at Kansas City, if plans just formed are carried out. A large dam is to be built across the Kaw River, and the dynamos will be run by water power. It is expected that from this station electric lights can be supplied for Kansas City and all the neighboring towns, and that power can also be furnished to manufacturing establishments on a large scale.

THE latest plan for connecting the Long Island railroads directly with those of the main land has been brought forward by Mr. Erastus Wiman, who proposes to build a tunnel from Staten Island under New York Harbor near the Narrows to a point on the Long Island shore, thus practically extending the Baltimore & Ohio from its Staten Island freight terminus to a connection with the Long Island Railroad. Preliminary examinations, it is said, show that the building of such a tunnel is entirely practicable. Its total length will be about two miles. A company has been already incorporated.

THE Forestry Division of the Department of Agriculture has collected statistics of the number of ties used yearly in renewals on 112,455 miles of track in the United States, and also of the lumber used for bridges and other purposes on the same mileage. Calculating on this basis for the mileage not covered by these reports, it is estimated that the number of ties used yearly in the United States for renewals is 60,034,647, while the consumption of other lumber amounts to 681,407,511 ft. B. M.

Necessarily this is only an approximation, and it is believed to be under the truth, since an estimate of the whole number of ties in use shows that if only 60,000,000 were renewed yearly the average life of a tie would be about 8¾ years. A life of 6¼ years and a yearly consumption of 80,000,000 is believed by the Forestry Division to be nearer the truth.

In several sections of the country decreasing supplies are reported, and it is necessary each year to transport ties greater distances. The various processes for preserving ties and timber seem, nevertheless, to be making very slow progress.

THE Fortification Bill, which has been pending for some time on account of the differences between the Senate and the House of Representatives, has been finally completed by a conference committee and has passed. The appropriation of $1,021,000 to complete the gun-factory at the Watervliet Arsenal was dropped from the bill, but it is said that there was an understanding that provision for this purpose will be made at the next session. The Senate amendment providing that 50 per cent. of the forgings now being made may be finished and assembled by private contract went into the bill, as also the amendment appropriating $50,000 for testing pneumatic gun-carriages and high explosives, and that authorizing the purchase under contract of 100 guns, 25 of them to be 8 in., 50 to be 10 in. and 25 to be 12 in. caliber. The appropriation for new tools at the Watervliet gun-shops was made $320,000.

Other appropriations for new work include $25,000 for gun and mortar batteries at Boston, $726,000 at New York and $260,000 at San Francisco; $500,000 for land for fortifications; $200,000 for finishing heavy guns; $400,000 for 12-in. rifled mortars and $225,000 for carriages for the same. Provision is also made for experiments with torpedoes and submarine mines, for heavy artillery practice and for steel armor-piercing projectiles. Upon the whole the bill is as liberal as the Ordnance Department could expect.

ANOTHER failure has been recorded in an attempt to use high explosives with cannon of ordinary pattern. In the present case the experiments were made with a type of steel shell invented by Dr. J. G. Justine, and the experiments were made under his charge at Perryville, N. Y. The gun used was a Blakeley rifle, and several trials has previously been made with it, using shells weighing about 330 lbs., carrying a charge of 18 lbs. of dynamite and projected by 35 lbs. of powder. In the test in question the charge of dynamite was somewhat less, and the gun exploded on the first shot, pieces of it being thrown in every direction. A large number of persons witnessed the experiment, but fortunately no one was hurt, owing to the precautions taken.

The gun was 9 in. bore, and the shells used were 44 in. in length, consisting of an outer shell of steel $\frac{7}{16}$ in. thick, enclosing an inner shell containing the dynamite, the space between the two shells being packed with a compound made by Dr. Justine. The exact cause of the explosion is not yet known, but it appears to have resulted from premature explosion of the charge of the shell.

THE Navy bill, as it finally passed Congress, is a compromise between the House and the Senate bills. It provides for six new ships, three of which are to be battle-ships of about 9,000 tons displacement, with a belt of 18-in. armor and carrying each four 13-in. guns, with a number of 8-in. and 6-in. guns; a fourth is to be a protected cruiser of large size—7,500 tons displacement—and high speed, with a heavy armament; the others are a torpedo cruiser of 750 tons and 23 knots speed, and a torpedo-boat similar to the *Cushing*. The authorized cost of the six ships. not including guns, is $15,225,000. Bids have already been asked for the three battle-ships.

Minor appropriations provide for the completion of the gun-making plant at the Washington Navy Yard; for the building of timber dry-docks at Port Royal and at some point on the Gulf of Mexico; for testing projectiles and armor-plates, and for testing a submarine gun.

THE RAILROAD YEAR.

ON another page will be found some figures from the summary given in *Poor's Manual* of the operations of the railroads of the United States during the past year. These figures are of interest as including the operations of practically all the railroads of the country, though the period covered varies, the fiscal year reported for differing with different companies.

For the last two years, however, the Interstate Commerce Commission has required reports from all the railroad companies subject to its authority. These reports cover a uniform year—that ending with June 30—and Mr. Adams, the Statistician of the Commission, has just completed a summary of the reports received for the year 1888–89, which include 153,385 miles of road, operated by 609 companies.

The figures show the magnitude of the railroad interest, for the stocks of the reporting companies amounted in all to $4,251,190,718, and the bonds to $4,267,527,859, a total nominal capital of $8,518,718,577.

The total earnings of the roads for the year were $964,816,129, an average of $6,290 per mile; the working expenses were $644,706,701, or 66.8 per cent. of the earnings; the net earnings were $320,109,428, an average of $2,087 per mile of road, and 3.8 per cent. on the nominal capital. After deducting $218,720,692 for fixed charges, there remained an apparent net profit of $101,388,736, or 2.4 per cent. on the total stock. The dividends actually paid amounted to $82,110,198, an average of 1.9 per cent. on the total stock; but a very large part of the stock received no dividend.

The year was generally a prosperous one for the railroads, and the total amount invested in improvements of road and additional rolling stock must have been very large.

ENGLISH AND AMERICAN LOCOMOTIVES AGAIN.

IN the JOURNAL for July we summed up the results of a triangular discussion of this subject by three of our cotemporaries. Up to the date of the publication of this summary our courageous American cotemporary, *Engineering News*, had not responded to the accepted challenge of the *Engineer*, to show wherein American locomotive boilers are superior to those made and used in England. In the number for July 18 the *Engineer* breaks the silence on this subject, which apparently had grown oppressive to its editors, and in an article endeavors to show wherein and wherefore English locomotive boilers are better than those made in America. In commenting on the part that "the oldest railroad paper in the world" has taken in the controversy, it says that "the last number contains a very amusing article summing up the whole controversy, so far as it has gone; but neither does it add

anything to the available store of facts." This observation may remind the reader of the man who went to hear Artemas Ward lecture and came away saying that the lecturer "was the blamedest fool he had ever listened to."

So far the controversy has not been very instructive, but it has been amusing. But where is Edward Bates Dorsey? If he would only enter the ring and "slash around" a little, the fun would doubtless grow fast and furious.

The *Engineer's* article of July 18 may be summed up by the statement that American locomotives do not evaporate more than from 5 to 7 lbs. of water per pound of coal, whereas English locomotives evaporate from 7 to 10 lbs.

This statement is very indefinite. Does our cotemporary mean that in ordinary practice our locomotives do not evaporate more than from 5 to 7 lbs. of water per pound of coal? If it means that it may be true, but it is an idle assertion, because nobody knows what they do, as there are comparatively few roads on which an account of fuel consumption is kept, and none of their officers ever thought of keeping a record of water consumption. If the above hypothesis of our cotemporary's assertion is its true meaning, it is nothing more than a wild guess or assumption, because nobody knows, or can know what they evaporate.

If, on the other hand, it means that in cases where a careful record has been kept of the fuel and water consumption, that our locomotives have not evaporated more than from 5 to 7 lbs. of water, the assertion has the serious fault of not being true, and the first real blow in this contest must be declared to be a "foul."

In evidence of this some experiments may be quoted which were made by the writer as far back as 1873 with an ordinary American four-coupled engine with four-wheeled truck, 17 × 24 in. cylinders and 5-ft. wheels. The maximum grades on which the experiments were made were 30 ft. per mile, the number of miles run 145 for each experiment, with the following results:

Weight of Cars Hauled.	Water Evaporated Per Pound of Coal.
Tons of 2,000 Pounds.	Pounds.
754.43	7.04
748.62	7.32
559.82	8.02

The train consisted of freight cars; the average running time was less than 20 miles per hour. The two heaviest trains were the maximum loads the engine could haul, or, rather, were greater than could be hauled, as in both trips it had to be helped up a short grade combined with a sharp curve. The fuel was Indiana coal, which is of poor quality if compared with that from Pennsylvania and Cumberland mines. The locomotive with which the experiments were made did not represent the best practice of that time—1873—and the best locomotive of to-day would undoubtedly give better results than any that could have been obtained at that date.

It will be noticed, from the figures which have been given, that the evaporation per pound of coal was considerably greater with the lightest load than it was in the two other cases, a fact of some importance which will be referred to again.

On the Grand Trunk Railway of Canada experiments have been made with an ordinary American engine with 17 × 24 in. cylinders, four-coupled 5-ft. wheels, and four-wheeled truck, with 38,864 lbs. of adhesive weight on the driving-wheels. The tests were made in July, and each test consisted of a run of 250 miles, with the following results:

Weight of Cars in Tons of 2,000 Pounds.	Water Evaporated Per Pound of Coal.
560	7.71
595	8.09
578	7.88
617	7.18
621	7.40
573	6.79
610	6.67
590	7.32
558	7.10

These experiments were made with an American type of engine, not of the most recent construction, and under the supervision of Englishmen, and without an extended smoke-box.

The above data give the results of such experiments only as are at hand at the present writing, and doubtless some of our readers could furnish many reports of other tests showing better results.

Our foreign cotemporary, in accounting for the hypothetically unsatisfactory performance of the American boiler, says further: "To get the full value out of coal there must be a brick arch in the fire-box, . . . if a brick arch is used the fire-box must be of copper."

Wrong again, esteemed cotemporary; you struck below the belt. It may surprise you to learn that on the Grand Trunk Railway which, with the exception of a few antiquated types of English engines, is equipped with American locomotives, most of them built in the United States, but under the management of your countrymen, there is not a single engine with a copper fire-box and not one without a brick arch. Briefly, it may be said that the use of the brick arch is very common in this country, but by no means universal. Your hypothesis and statement of fact are both wrong. Therefore the superiority of English locomotive boilers cannot be due to the causes assigned by you.

You have referred to the experiments made on the Paris, Lyons & Mediterranean Railroad. By studying these carefully you will see that the use of the brick arch reduced the quantity of coal which could be burned in the grate. Now the question arises, Will a locomotive do as much work with a brick arch in the fire-box as one will without? American locomotives are built to do work and as much of it as possible. On roads where coal is cheap the wages of the locomotive runner and fireman cost as much as the fuel does. If, therefore, they—the locomotives—pull, say, 10 per cent. more cars, the company is saving in wages as much money as it would if it hauled fewer cars and saved 10 per cent. of the coal burned. This does not take account of the conductors' and brakemen's wages, which are equal to or greater than those of the fireman and "driver," as you call the accomplished individuals who run the locomotives in your country. Preposterous as the statement may seem in many cases, it does not pay to save coal.

In making comparisons of the relative amount of water evaporated per pound of fuel by different boilers, the rate of combustion should be taken into account. Attention has been called to this in the experiments first quoted. Leaving out the odd figures, with an average load of 750 tons the evaporation averaged 7.16 lbs., whereas with only

560 tons it was over 8 lbs. We have also seen a report of an experiment made on a leading railroad by running an engine over the line without any load, which showed an evaporation of over 9 lbs. With a heavy load the same engine evaporated only a little over 6 lbs. It would throw some light on this subject to know how much coal you are burning in English locomotives. In some experiments with a passenger locomotive on the Grand Trunk Railway, it was found that the average coal consumption per square foot of grate per hour was as follows: 121.7, 106.3, 122.4, 135.1, 115.4, 127.5, 125.4, 119.3 lbs. Last month we reported some of the results of experiments on the Baltimore & Ohio mountain grade, showing that in one instance—not an unusual one either—193.7 lbs. of coal was burned per square foot per hour. Under such conditions the rate of evaporation would probably be low, but they are the conditions which control the working of locomotives on that part of the Baltimore & Ohio line. The boilers must burn that quantity of coal or the locomotives cannot take their trains up the grade 17 miles long and rising at the rate of 117 ft. per mile.

Now, most esteemed cotemporary, you are crying out for facts and light, will you not turn your mental search-light on the railroad lines of your country and tell us what quantity of fuel you are burning in given periods? When you evaporate from 7 to 10 lbs. of water per pound of coal, how much coal are you burning per square foot per hour. In some cases we find it desirable to abandon the brick arch in order to increase the capacity of the boiler to burn coal. With a high rate of combustion our engines can take their trains, whereas without it they cannot, and it is found more satisfactory to burn a little more fuel than to have trains delayed.

The fact is, fair comparisons of locomotive performances are extremely difficult, unless they are made from records taken on the same line, with the same fuel and trains and under exactly the same conditions. It seems probable that American locomotives generally are worked harder than English locomotives are, and the differences in their performance are due more to that fact than to any inherent superiority in either.

Whether British coal is better than American, or English firemen are more skillful than their Yankee craftsmen, is not worth discussion in the absence of any means for testing the merits of either. It may, however, be said safely that there is a great deal of difference in the quality of both American fuel and American firemen. In the Western States there is a good deal of what may be called cussedness in both, but they do their work effectively, although there is often considerable sulphur combined with the carbon of the one, and the conversation of the other. Nevertheless, it would be entertaining if an opportunity were given to some of our firemen to handle a shovel in competition with a picked team of their English brethren.

To go back to the evaporation of English locomotive boilers, will the *Engineer* give us more exact statements of the circumstances under which they evaporate from 7 to 10 lbs. of water? After considerable amount of reading of railroad literature, and some observation on British roads, we never heard an intimation that any account is kept of the consumption of water on them in ordinary practice. If such an account is not kept, the data given by our cotemporary must have been obtained from some experimental tests which were carefully recorded. Give the circumstances and the particulars of those tests—the dimensions of engines, loads hauled, grades, speeds, distance run, were feed-water heaters used, did the injectors waste water, did the engines work dry steam, did the fuel consumption include that burned in firing up or raising steam? There are many circumstances which influence the results which should be known to be able to make fair comparisons. But, as remarked before, unless two locomotives are run on the same line, under exactly the same conditions, comparisons which will prove anything are difficult, if not impossible.

In its issue of August 2, *Engineering News* says that the weather has been too hot to discuss this subject very seriously; but it publishes a long article to show that we haul heavier train loads in this country than they do in Europe, which is doubtless true. As the *Engineer* remarks, at this rate we are not making much progress. Our foreign cotemporary's evidence breaks down on cross-examination, and our neighbor assumes a defensive attitude. It is not quite clear what the question at issue is, but it is safe, for the present, to hurrah for the American Eagle.

If it were possible to do so it would be very interesting and instructive if some railroad company, in a country foreign to the United States and to England, should give an order to some British locomotive building firm or company and another to an American establishment, instructing each to build a locomotive which, in their opinion, would be best adapted for freight or goods traffic where average running speed should not exceed 30 miles per hour. The engines alone, without the tenders, to weigh in working order 100,000 lbs., the weight per wheel not to exceed 12,500 lbs. When completed, the engine to be put to work beginning with light loads and gradually increasing them up to their maximum limit, a careful account being kept of the coal consumption, cost of repairs, and the general performance of the engine. Such an experiment would interest the whole railroad world and would be very instructive; but as there does not seem to be any immediate prospect that this will be done, we will suggest to our cotemporaries that they each design a locomotive to conform to these conditions, give full specifications of them, and publish the latter and engravings showing the designs and lay them before the public for criticism. Then will there be something definite to discuss, whereas the "American and English locomotives" are now only vague entities.

THE HARLEM BRIDGES.

The Governor of New York withheld his approval from the bill passed by the Legislature at its recent session, which provided for the raising of the bridges over the Harlem River, thus leaving the much discussed question of the crossings of that river precisely where it was.

The question, being chiefly a local one, may require some explanation. The river traffic on the Harlem at present consists largely of barges and tug boats, the number of vessels with masts being comparatively small. There is no through navigation at present, for while the Harlem and the Spuyten Duyvil Creek together extend from the East River to the Hudson, a section is not navigable. Surveys have been made, however, and there have been some appropriations for deepening, widening and opening the channel so as to enable vessels of considerable size to pass through, and the advocates of that work anticipate that when it is completed the channel will be used largely

as a short cut by vessels coming down the Hudson and bound up Long Island Sound, and *vice versa*, while at the same time the river front will be a considerable addition to the dockage capacity of the city. Most of the bridges over the Harlem are now at a comparatively high level, enabling the ordinary barge traffic to pass underneath them, but two of the principal crossings—the bridge of the New York Central & Hudson River Railroad at Fourth Avenue and the Third Avenue highway bridge, belonging to the City—are low, about 15 ft. above high water, so that the draw-spans of both of these bridges have to be opened to permit the passage of the smallest vessels. The number of trains on the Central is very great, and there is an enormous traffic over the Third Avenue Bridge also, to which the frequent opening of the draws has grown to be an almost intolerable interruption, causing constant and very annoying delays, which would, of course, be very much increased should the ship channel through the river be opened. The bill, to which reference is made above, provided for the raising of these bridges to a height sufficient to permit all ordinary tugs and barges to pass beneath them, and in that case the draws would only require to be opened for masted vessels, which are at present comparatively few in number.

The problem of making any change in the crossing is complicated by the fact that the Central Railroad grade was lowered a number of years ago through the City in order to separate it entirely from the street grades, and that the Company is now expending a large amount of money on a similar work north of the river, which is nearly completed. To raise the bridge crossing 25 or 30 ft. as proposed would involve a heavy expense in changing the present grades, and would also interfere very seriously with the street crossings of the railroad, and the same trouble would be found in changing the grades on Third Avenue, which is one of the principal thoroughfares of the City. Hence it has been proposed in the interest of property owners to tunnel the Harlem and to do away entirely with the bridge crossings, but to this also there are very serious objections. The engineers of the Railroad Company claim that for a tunnel it would be necessary to go at least 60 ft. below the present grade, and the cost of such a lowering of the track, as can be easily seen, will be enormous, while very serious engineering difficulties would be involved. They also claim that this cost would be altogether out of proportion to the benefits to be derived from opening the course of the river, which they claim would accrue principally to the owners of property immediately adjoining its banks.

There is much reason in these arguments, for while a tunnel crossing presents no engineering difficulties which could not be overcome, there is no doubt that the cost would be very great. The traffic crossing the river is at present very much greater and of more importance to the City than that which is carried on it, and if the convenience of the traveling public alone is consulted, the latter should give way; but water traffic has by law certain rights which cannot be disregarded. At present, while the tunnel solution of the problem seems in many respects the most desirable, the raising of the bridges also seems to be the most convenient, practically the main objection to that being that it is only temporary in its nature. As the matter stands, however, it is not likely that anything will be done for another year.

This is only another case of the difficulties which inevitably arise over railroad entrances into large cities, the majority of which have been originally laid out at a time when no one did or could foresee the extent of the future growth of the railroad travel or of the City itself.

THE ISTHMUS CANALS.

The Commission of French engineers, which was appointed to examine the Panama Canal and to see what could be done toward its completion, has made a report to the receivers who are now in charge of the Canal Company. Although the Commission is somewhat hopeful, it must be confessed that the facts given in its reports are anything but encouraging to investors. After carefully examining the ground the Commission recommends the completion of the canal in four sections, the first a summit level about 114 ft. above the level of the sea and about 12½ miles in length. This level would form a long and narrow lake, enclosed between two great dams barring respectively the valleys of the Chagres and the Rio Grande, and fed mainly by the waters of the former stream. Below this would be an intermediate level forming a second narrow lake, while at either end would be a stretch of canal at the sea level about 7½ miles in length at the Panama end and 15 miles at the Colon end of the canal. The communication between the different levels would be made by two double series of locks on the Atlantic end and by one double and two separate locks at the Pacific end. These locks as proposed would have a lift of from 30 to 36 ft. each, and would have an available length of about 600 ft. and a width of 66 ft. The engineers of the Commission believe that the long summit level or lake would provide sufficient room for the waters of the Chagres to expand without overflowing—a conclusion which seems scarcely warranted by the facts.

However its opinions may be regarded from an engineering point of view, financially they are not by any means encouraging. The estimated expense of completing the canal upon this plan is about $120,000,000, the principal items being $60,000,000 for excavation and $22,000,000 for locks. To this must be added the general expenses of the Company and interest upon the new capital to be raised, which will bring the total amount up to about $180,000,000, representing the amount which will have to be provided in addition to that already invested in the Company, while the time required will be about eight years. On the other hand, the estimates given of the return to be expected seem somewhat sanguine, for the annual cost of management and maintenance of the canal is put down at $2,000,000 only, while the return from traffic, it is estimated, will reach about $8,000,000 at the end of the fourth year after the opening and $12,000,000 at the end of the tenth year. Even with this estimate it is difficult to see how any reasonable return can be promised on the capital to be raised, while the prospect for the old securities of the company is very remote indeed.

It is also to be noted that in all this no account is taken of the probable construction of the Nicaragua Canal, all the estimates made looking to the Panama Canal as the only communication between the two oceans. It may also be said that a large allowance has been made for the value of the work already done and of the plant now on the Isthmus, and apparently very little allowance has been made for the rapid depreciation of both.

While the prospects of the Panama Canal are thus doubt-

ful, work on the Nicaragua Canal is advancing steadily, and there is every prospect that the work will be carried through. The company has now a considerable force on the line, and fair progress has been made on the preliminary works, so that in a short time everything will be in readiness for actual construction on the more difficult sections.

One very great advantage of this line is the much better climate and the consequent absence of much of the difficulty found in securing labor which has always been so serious a trouble at Panama. Of course labor must be imported to a considerable extent, but it is possible for the men to work and live, the chances of which at Panama were very small.

In Lieutenant Barroll's articles on Interoceanic Canals, published recently in the JOURNAL, are given some of the reasons for the failure of the Panama enterprise, and a careful reading of those articles will show causes quite sufficient to account for it.

NEW PUBLICATIONS.

UNITED STATES DEPARTMENT OF AGRICULTURE, FORESTRY DIVISION, BULLETIN NO. 4. REPORT ON THE SUBSTITUTION OF METAL FOR WOOD IN RAILROAD TIES: BY E. E. RUSSELL TRATMAN, C.E.; TOGETHER WITH A DISCUSSION ON PRACTICABLE ECONOMIES IN THE USE OF WOOD FOR RAILROAD PURPOSES: BY B. E. FERNOW, CHIEF OF THE FORESTRY DIVISION. Washington; Government Printing Office. Published by Authority of the Secretary of Agriculture.

This latest publication of the Forestry Division is chiefly made up of Mr. Tratman's final report on the Substitution of Metal for Wood in Railroad Ties, which gives at considerable length and with much detail the development of the use of metal ties and the present state of the question. Most of the reports are from foreign countries, since experience with metal ties in the United States has not, thus far, been extensive, although practical tests on a considerable scale have been begun. The report is accompanied by diagrams showing forms of iron and steel ties used in England, France and Switzerland; the Post tie used in Holland; the Berg & Mark tie in Germany; the Hohenegger tie in Austria, with several other forms; the pot and plate ties (cast iron) largely used in India; and finally the Hartford, the Toucey, the Standard and other forms of tie now being introduced in the United States.

Mr. Tratman's paper is prefaced by a report on the consumption of timber for railroad purposes, and by a short but interesting paper by Mr. B. E. Fernow, Chief of the Forestry Division, on Practicable Economy in the Use of Forest Supplies, treating of the best methods of prolonging the life of ties, including care in selection and handling; the use of tie-plates and similar devices, and various methods of chemically treating timber to prevent decay.

The subject is one that calls for attention, and this Bulletin should be read by railroad officers everywhere with care. The Forestry Division is doing excellent work in this direction.

MANUAL OF THE RAILROADS OF THE UNITED STATES FOR 1890: TWENTY-THIRD ANNUAL VOLUME. New York; H. V. & H. W. Poor, 70 Wall Street.

The yearly appearance of *Poor's Manual* has now come to be looked for as a regular event, and its reputation is so well established that there is really very little to be said of a new volume. As the only work of the kind, and an indispensable reference-book for investors and all others who are interested in railroads, it holds its place fully and will apparently continue to hold it.

That it has some defects is true, but most of them are really inherent in the manner in which it is necessarily prepared, as an unofficial publication. That on this basis it should be as complete as it is must be considered as due entirely to the care taken in its preparation, and the standing it has acquired by long-continued publication. One improvement which might be suggested is a more systematic arrangement of the companies, so that continual reference to the Index would not be necessary for those who have to use the *Manual* frequently. This is a minor matter, but is, perhaps, worthy of attention.

An improvement introduced this year for the first time is in the publication of separate maps of a number of the more important railroad systems. These are large enough to give a general idea of the position and relations of each system, and are given in addition to the general maps which have heretofore appeared.

The summary or introduction to the *Manual* gives some statistics of much interest. Some extracts from it will be found on another page.

MINERAL RESOURCES OF THE UNITED STATES FOR THE YEAR 1888: BY PROFESSOR DAVID T. DAY, CHIEF OF THE DIVISION OF MINING STATISTICS AND TECHNOLOGY, UNITED STATES GEOLOGICAL SURVEY. Washington; Government Printing Office.

The report on the mineral resources of the United States, of which the present is the sixth volume, long ago reached the rank of a standard authority upon the subject, the care with which it is prepared and the intelligence with which it is arranged and edited meriting high praise. Perhaps the statement made in the introduction to the volume itself will best express the method of arrangement as follows:

In this report the method of treatment in previous volumes has been continued. The report opens with a summary statement as to the condition of each mineral industry at the close of the period under review—the calendar year 1888. There is no attempt in this place to show the products of separate sections of the country. The division is entirely according to the minerals themselves. At the close of this summary is a table in which the values of the various products are added, so as to furnish an estimate of the relative importance of the mining industry as a whole. Following the summary, each important mineral industry is discussed in a separate chapter. The statistical tables given in former reports have been extended to include 1888, but otherwise the material in each chapter is intended to show the developments in 1888, and not in previous years. It is expected that the readers will consult the corresponding chapters of the six reports which constitute the series. For this purpose an index to the six volumes is in preparation.

In all publications of this kind some delay is inevitable, and the appearance of this volume is somewhat late, owing to the fact that it covers so many diverse topics. It has been, however, the practice of the Geological Survey to publish summaries of the more important proofs of the report as soon after the close of the period covered as possible, so that the statistics relating to the leading mineral products are accessible some time before the completion of the book.

NATIONAL CAR & LOCOMOTIVE BUILDER SUPPLEMENT. New York, July, 1890.

This *Supplement*, which is issued yearly by Mr. John N. Reynolds, from the office of the *National Car & Locomotive Builder*, contains a very useful directory, giving the names of all the makers of cars, locomotives, car wheels, axles and springs, and of all the rail mills in the United States. It has also a list of the officers of the street railroads of the United States, and of the railroad companies of South America—information not always to be found elsewhere.

As an advertising sheet, the *Supplement* might almost be taken for a directory of all the manufacturers of and dealers in rail-

road materials and supplies, for very few of them are absent from its pages.

BOOKS RECEIVED.

REPORT OF THE SECRETARY OF THE NAVY, 1889. PARTS I. AND II. Washington; Government Printing Office. These two volumes contain not only the Report of the Secretary, but also all the reports of the Bureaus of the Department, giving a complete history of a year of very active work on the enlargement of the Navy.

SECOND ANNUAL REPORT ON THE STATISTICS OF RAILROADS IN THE UNITED STATES, TO THE INTERSTATE COMMERCE COMMISSION, FOR THE YEAR ENDING JUNE 30, 1889. Washington; Government Printing Office. Some figures from this report will be found on another page.

REFERENCE BOOK OF THE NORFOLK & WESTERN RAILROAD COMPANY. Philadelphia and Roanoke, Va.; issued by the Company. This is a guide or hand-book intended to show the present condition of industrial progress in Southwestern Virginia, and to give some idea of the natural resources of that region, and especially of the sections reached by the Norfolk & Western Railroad and its branches. It is profusely illustrated.

REPORT OF THE FIFTH ANNUAL MEETING OF THE ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS, HELD AT PEORIA, ILL., JANUARY 29-31, 1890. Springfield, Ill.; published for the Society; S. A. Bullard, Secretary.

SPECIALTIES IN HARDWARE: ILLUSTRATED CATALOGUE NO. 7. New York; issued by Tower & Lyon.

CORNELL UNIVERSITY, COLLEGE OF AGRICULTURE: BULLETIN OF THE AGRICULTURAL EXPERIMENT STATION, NO. XVIII, JULY, 1890. Ithaca, N. Y.; published by the University.

AUTOMATIC QUICK ACTION AIR BRAKE SYSTEM. TEMPORARY CATALOGUE OF THE BOYDEN BRAKE COMPANY: ILLUSTRATED. THIRD EDITION, AUGUST, 1890. Baltimore, Md.; issued by the Company.

ABOUT BOOKS AND PERIODICALS.

IN the SCHOOL OF MINES QUARTERLY for July, W. H. Weed writes on Geysers; Lieutenant John W. Ruckman on the Wind Problem in Gunnery; T. J. Brereton on Turnouts; R. V. A. Norris on Anthracite Mine Surveying; and there are several other artices of interest in their respective lines.

In the number of HARPER'S WEEKLY for July 26 there is a spirited sketch of one of the new battle-ships for the Navy as it will appear when completed. The WEEKLY has reflected the popular interest in the Navy, and has had from time to time excellent illustrations of the new ships. The same paper for August 13 has a sketch and description of the 7,300-ton cruiser, and the number for August 20 has an illustrated description of the manufacture of heavy guns for the Navy.

In the ARENA for August Professor N. S. Shaler has an interesting article on the Economic Future of the South. There is an excellent article on Foreign Immigration, and others on various timely topics. This magazine, indeed, has always something worth reading; its articles are usually on live questions, and whether we agree with the writers or not, we are forced to admit the ability and suggestiveness with which their views are presented.

There will be found in BELFORD'S MAGAZINE for August, besides the usual assortment of fiction and lighter matter, articles on the Original Package Decision, by B. J. Sage, and on Canada under Protection, by Hon. J. W. Langley. A paper on Literature in Louisiana, by Judge Gayarré, is very interesting for the general reader.

In HARPER'S MAGAZINE for September the article Across the Andes, by Theodore Child, is an illustrated description of the great South American Transcontinental line which will, when completed, extend from Buenos Ayres to the Pacific at Valparaiso. This is the first of a series of articles on the South American republics. The Mountain Passes of the Cumberland, by James Lane Allen, is an account of the growth and development of the rich iron region of Kentucky and Southwestern Virginia.

Engineers, and others also, will find Dr. Groff's article on Sanitary Work in Great Disasters, in the POPULAR SCIENCE MONTHLY for August, of much interest. In the same number Robert H. Scott writes of Thunder Storms, and Dr. Klein of Invisible Worlds. In the September number F. J. H. Merrill —in Barrier Beaches of the Atlantic Coast—gives an account of the building up and washing away of the narrow sandy islands near Sandy Hook, Long Branch and Cape May, illustrating similar action that is going on all along our eastern shores.

In the OVERLAND MONTHLY for July the articles on Corporations, Trusts, Labor and Capital are concluded. The OVERLAND is always interesting reading to those who wish to know something of social and economic conditions on the Pacific Coast.

Among the articles in the STEVENS INDICATOR for July are Notes on Friction of Engines, by Professor J. E. Denton; Fabrication of 12-in. Mortars, by A. A. Fuller and F. N. Connet; Identification of Dry Steam, by F. E. Idell; Examination of Lubricating Oils, by Professor T. B. Stillman; Cable Traction for Elevated Railroads, by C. W. Thomas; New Method of Extracting Cube Root, by Professor H. A. Wood; New Recording Pressure Gauge, by Professor W. H. Bristol. This number will be of interest to graduates of the Stevens Institute, as it gives a full report of the Commencement and Alumni meeting.

THE NEW BATTLE-SHIPS.

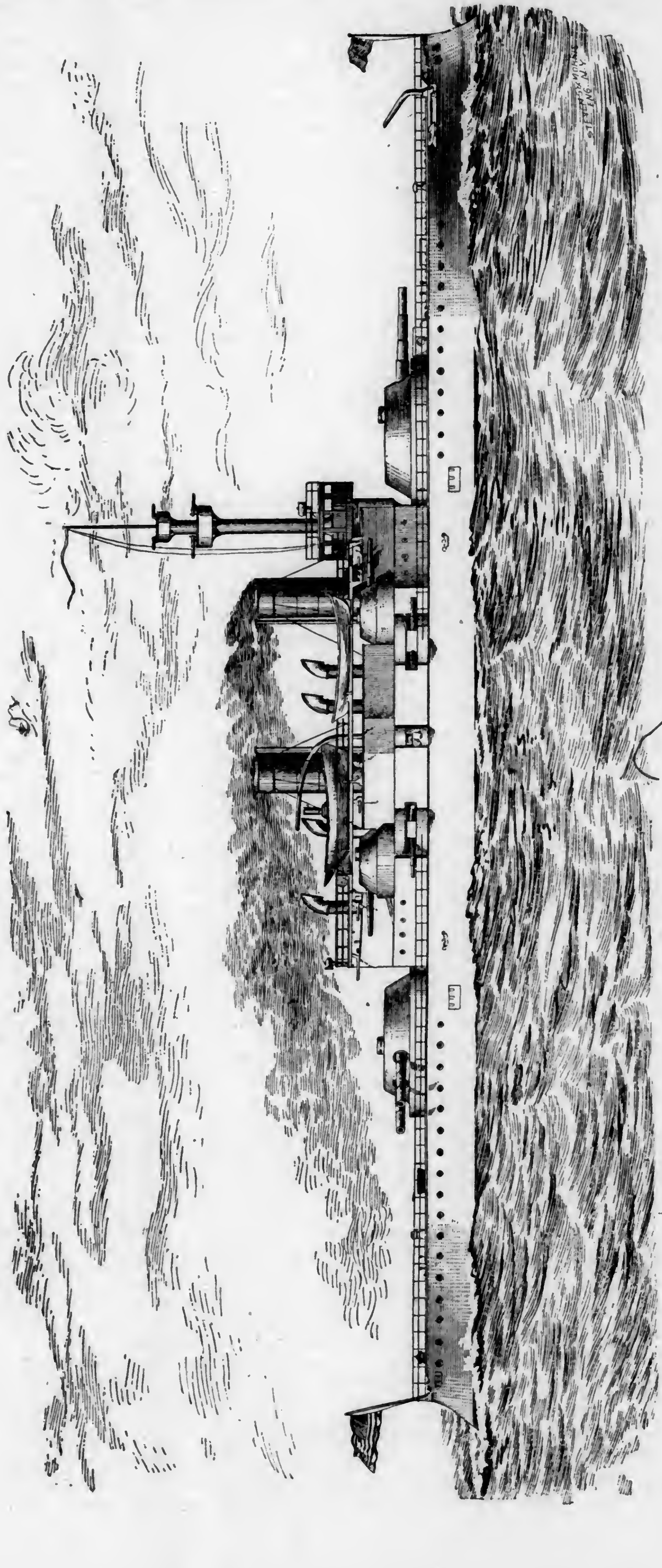
THE accompanying illustration, which is from a photograph furnished by the Navy Department, shows the general design adopted for the three battle-ships authorized by the Navy Appropriation Bill for 1890. The designs for these ships were made in the Department, and their cost is not to exceed $4,000,000 each.

The following are the general features and dimensions of these ships: Length on load water-line, 332 ft.; extreme breadth, 69 ft.; mean normal draft, 24 ft.; normal displacement, 9,000 tons; normal sea speed, 15 knots per hour.

The main battery will consist of four 13-in. breech-loading rifles; the auxiliary battery of four 8-in. and four 6-in. breech-loading rifles; the secondary battery of twelve 6-pounder and six 1-pounder rapid-fire guns and two Gatling guns.

The 13-in. guns are mounted in pairs on the center line under protection of improved steel turrets 17 in. in thickness, working inside of a raised barbette with steel armor 17 in. in thickness. These barbette-turrets are of the same type as those adopted for the *Puritan*, *Amphitrite*, *Maine* and *Monterey*, and are of the latest improved design; the armor of the turrets being inclined, offers a resistance equal to that of 19 in. horizontally placed.

The 8-in. guns are mounted in similar barbette-turrets 6 in. in thickness. The ammunition is supplied through armored tubes, and every consideration has been given to realizing as rapid a service as possible. The four 6-in. guns are fought under protection of 4 in. of armor, and have the usual shields. The fire from four 13-in. guns, three 8 in., two 6-in., and eight 6-pdrs., can be concentrated on either bow or quarter.



THE NEW BATTLE-SHIP FOR THE UNITED STATES NAVY.

The water-line is protected by a belt of steel of a maximum thickness of 18 in., backed up by wood, behind which are two thicknesses of 3.4-in. plates powerfully stiffened by a system of vertical and horizontal girders. Above this belt is a casement of $5\frac{1}{2}$-in. armor to prevent riddling above the belt, and to break up projectiles charged with high explosives. Diagonal bulkheads are worked at the ends of the belt, and from the armored deck, which is worked over the vessel at top of belt, rise the redoubts, protecting the turning and loading gear of the turrets for the heavy guns. A deep belt of coal is carried above the armor-deck, adding still further protection against gun fire.

In wake of the boilers are four skins and a 12-ft. bunker of coal, making it practically impossible for a torpedo to make a hole that will let water into the fire-room.

Behind the armor of the belt and surrounded on all sides by coal are two wide passages, one on each side, connecting the passing rooms for ammunition at the ends, so that all the handling of ammunition will be well protected, and in these passages, lighted by electricity, the men can carry ammunition to the various tubes and trunks leading to the guns above.

The machinery for these ships has been designed by the Bureau of Steam Engineering. The twin screws will each be driven by a vertical triple-expansion engine, each engine being placed in a separate water-tight compartment. The cylinders will be $34\frac{1}{2}$ in., 48 in. and 75 in. in diameter and 42 in. stroke. Steam will be furnished to them by four double-ended main boilers 15 ft. in diameter, each having eight furnaces. Each boiler is in a separate water-tight compartment. In addition there will be two auxiliary boilers 10 ft. in diameter and 8 ft. 6 in. long, placed on the berth deck, from which the pumps and other auxiliary machinery can be run.

The engines are expected to develop 9,000 H. P. under forced draft and 7,000 H. P. under natural draft. The working pressure of steam is to be 160 lbs., and the engines will make 128 revolutions per minute when working up to their full power.

The vessels are to be built on the bracket system, with a double bottom extending from armor-shelf to armor-shelf, with many subdivisions and water-tight compartments. Every approved device adding to the health of the crew, the safety of the ship, and the efficiency in battle will be fitted. Each battle-ship will carry 450 men, including a marine guard of 36 men, and 30 officers. Especial attention has been paid to the ventilation and drainage. Any compartment can be quickly cleared of water in a short time by powerful hand and steam pumps, while air will be supplied to all the living and storage spaces by fans of ample capacity.

REPAIRING BRIDGE PIERS UNDER WATER.

(Note by M. Rossignol in *Les Annales des Ponts et Chaussées.*)

THE Bridge of Joigny, on which the National Road No. 6 crosses the Yonne, was constructed about the middle of the eighteenth century. Since that time it has undergone different changes. The road was widened by substituting an iron railing for the old stone parapet. The approaches have been improved. On the right bank a tow-path and a river arch were united by replacing two smaller arches by a single one, but no change and no repair seems ever to have been made to the foundations.

No record could be found relative to the method employed in building these foundations, but from the reports of boatmen who had dived down alongside of the pier, they appeared to be in a bad condition, and in the course of the year 1886 it was deemed prudent to have them examined by a diver.

This examination revealed the fact that in four piers out of five there were considerable failures. Moreover, the reports given by the diver on the first examination and other examinations, subsequently made when the repairs were begun, enabled the engineers to see in a sufficiently exact way the original arrangements of the foundation. These were similar for all the piers, and are shown in the accompanying illustrations. Fig. 1 is a plan of one of the piers divided into four quarters, that marked *W* being a quarter-section on the line of the framework of the timber platform ; *X* on top of the platform ; *Y* at the springing of the arch, and *Z* at the top of the piles. Fig. 2 is a section through the pier and foundation on the line *A B*, fig. 1 ; and fig. 3 is a cross-section on the line *C D*, fig. 1.

The masonry rested on a system of piling topped by a timber frame and a platform of planks, the upper face of which is 2.85 m. (9.35 ft.) below the level of the Joigny Dam, or about 1.25 m. (4.10 ft.) below low water mark.

The piles were embedded in concrete, but no remains of braces nor of planks were found indicating the arrangement of any frame or bed in which this concrete could have been placed to set. It therefore seems probable that when the bridge was built the engineers simply dredged out the gravel around the piles in such a way as to lay bare the chalk which forms the bed rock, and is 3 or 4 m. (9.84 or 13.12 ft.) at least below the low-water mark, and after the driving of the piles, beton was run into the hole thus formed. They could then have placed upon the concrete a small coffer dam in such a way as to enable them to pump out the inside, to set the piles, put in the concrete, build the frame and the platform, and finally build the masonry up to the level of the water.

The axis of the bridge is somewhat oblique in relation to the general direction of the bed of the river, in such a way that the current would act very slightly except upon the breakwater of the pier and on the left side of the piles. The result was that the right side of the foundation remained intact and was even partly covered by gravel washed up from the bed of the river, while the piers 2, 3, 4 and 5 were considerably undermined under the breakwater on the left side and even under the lower point of the pier on the line *a a a*, fig. 1.

The action of the current had been almost the same on all of the piers. The illustrations herewith given show as exactly as possible the effects on the foundation of pier No. 2, which was one of the most damaged.

The concrete was worn away by the friction of the gravel, and cracks produced by the eddies under almost all the surface of the breakwater, under the left side of the pier, and under a part of the starling. The piles set under the breakwater, with the first two rows under the left side

FIG. 1.

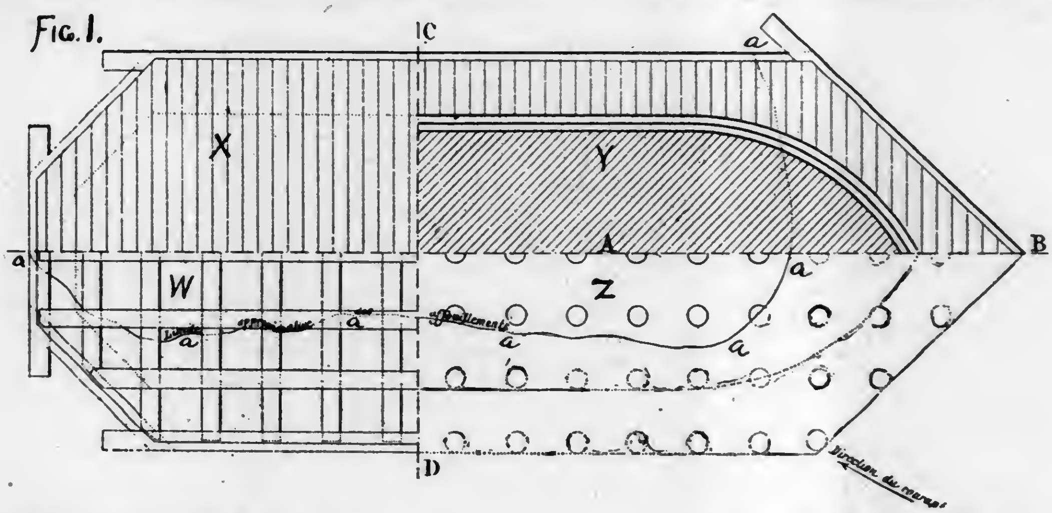


FIG. 2.

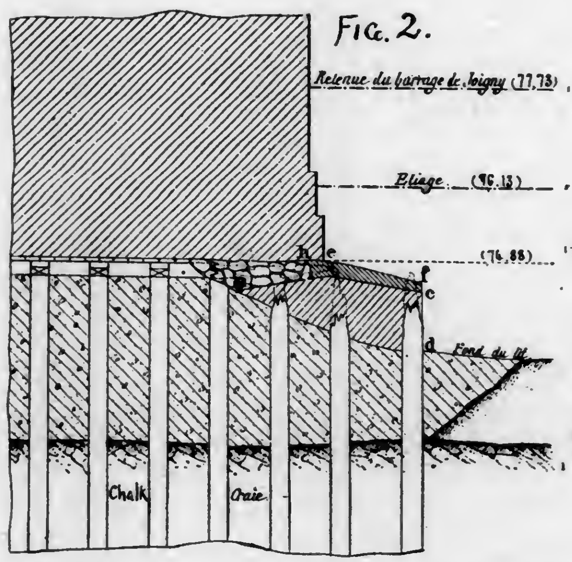
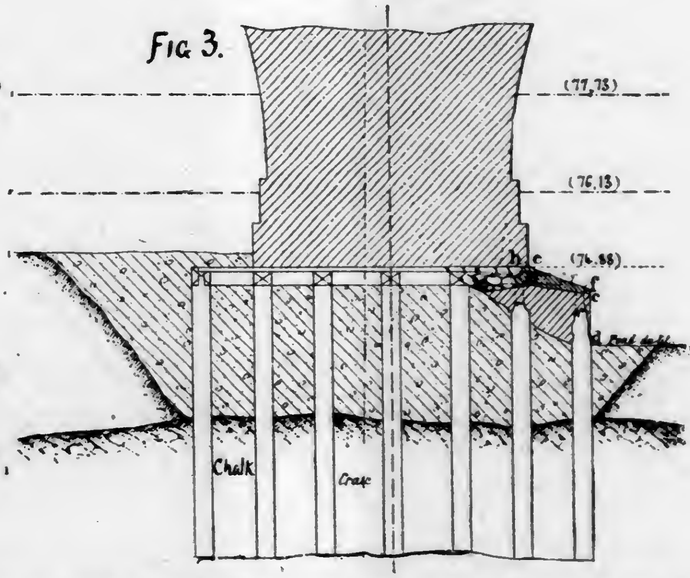


FIG. 3.



and the frame and planking which surmount them were very much decayed, and presented before the restoration of the foundations the form shown by the dotted lines in figs. 2 and 3. These pieces did not offer any sort of resistance, and the masonry over the decayed portion was really resting upon no foundation.

It was necessary, therefore, in order to restore these foundations, to proceed to a rebuilding and to protect the new masonry either by riprap or by additional masonry.

The last solution presented a double advantage. A water-table or bench of masonry resists a strong current much longer, while the riprap is rapidly displaced, and the old surface could be used safely for a foundation. Moreover masonry takes less space and consequently diminishes less the clear opening left under the arches for navigation.

To build this masonry dry, however, it would be necessary to make coffer-dams, which would have been expensive, since the chalk is at a considerable depth and is full of cracks. Moreover, it would not have been prudent to pump out the water around masonry piers, already much damaged and partly maintained in place by the pressure of the water.

It would have been possible to put in concrete under water. This operation, a very delicate one in itself, would have been made still more difficult by the presence of the remains of the piles and of the frame, and besides it would have been almost impossible to obtain perfect contact between the concrete and the lower part of the old masonry. The setting of concrete would, moreover, have been very costly, on account of the extent of the frame needed for a cube comparatively small.

Under these conditions Chief Engineer de Mas considered it best to make the repairs under water by means of divers, with masonry set in cement mortar, a proceeding which had already been used with success by M. Bonneau to repair the injuries to the wall of the Quay St. Maurice et Sens.

In that work the engineers had proceeded as follows: In the first place, the old masonry was carefully cleaned off, and the chalk upon which the wall was founded was cleared of the gravel which covered it. A small screen, or wing dam, was then made under water, by means of piles driven into the chalk and planks, in such a way as to turn aside the current. The blocks of stone were placed on the bottom by divers, and as fast as it was required quick-setting cement was lowered in small buckets filled level. The diver carefully turned over the bucket of mortar at the bottom of the pit in such a way as to allow it to spread without being washed away; then placed a stone block on it and so continued. It will be readily seen that this operation can be carried out without washing away the mortar, provided that care is taken to carry the bucket to the proper place before turning it over and not to move the stone after it has been placed upon the mortar. The use of the mortar, moreover, is made so quickly that the contents of a bucket cannot begin to set before they are covered over by a stone or by more mortar. The best proof that can be had is the experience obtained at Sens, where it was attempted after the work was completed to detach a block of the masonry, and it could only be done by breaking a part of the stone block.

The work of restoring the foundations at the Bridge of Joigny differed a little from that executed on the quay wall at Sens. The decay extended to a greater depth, and it would have been much more difficult to put in the masonry there, since the diver was obstructed by the remains of the piles and of the frame, which he had not been able to remove. It was therefore thought best to ram down sacks filled with cement mortar in all those parts which were not easily accessible. In doing this the engineers were assured beforehand that they would not have to fear the washing out of the mortar and that they could fill the gaps completely. By way of trial they had worked in some sacks of cement with blocks of stone in a large tub, and on examining it several days afterward they ascertained that there was no sensible washing away, that the mortar had set perfectly and that the sacks had molded themselves exactly to the stones.

Moreover, such masonry as had been built at Sens could be given only a very slight inclination, since it was necessary to allow the mortar to take its natural form. It was not thought after what had been seen at the Bridge of Joigny that it would be possible to obtain an inclination of more than 1 : 3 or 1 : 4. Under these conditions part of the advantage of the substitution of masonry for riprap would have been lost at considerable heights, since it would have been necessary to extend this masonry to a considerable distance from the piles, and moreover, part of it must have been founded on the gravel outside of the solid bottom formed by the old beton. Lastly the current at Joigny was much more rapid than at Sens, and it was a difficult matter to turn it aside by means of movable screens. The workmen themselves were led in the course of the work to propose to build the masonry in coffer dams made by nailing horizontal planks upon vertical joists fixed on the remains of the piers of the first line. The work was at last organized, as will be described below, taking pier No. 2, which is shown in the illustrations, as an example.

In the first place the decayed portion was cleaned away as completely as possible by removing the gravel, stones and débris of all sorts which covered the old beton and by cutting or chopping off, if necessary, the ends of the piles, the pieces of the frame, and the planks which could be removed. Sacks of cement mortar were then carefully rammed down, by an iron bar with a rounded head, into the gaps where it was not possible for the divers to reach with the masonry. This was hardly necessary except under the breakwater.

There was then put in place the first block of masonry marked by the letters *o*, *b*, *c* and *d*, figs. 2 and 3, commencing behind and advancing gradually toward the front, and leaving between this mass and the main body of the pier only sufficient space to pass in the sacks of mortar. This masonry was during the work protected against the current, and at the same time kept in place laterally, by planks, which were placed as the work advanced, and were fastened against the remains of the first row of piles. These were removed as soon as the mortar had set. The rest of the excavation was then filled to within about 6 or 8 in. back from the edge of the pier with sacks of cement mortar down hard; and then there was built the masonry marked by the lines *h e* and *f*, figs. 2 and 3.

Finally the old masonry now rests, to within 6 or 8 in. of the edge, on these sacks of cement, carefully rammed in after the height of the gap formed by decay had been reduced as much as possible with masonry. On the last 6 or 8 in. the pier rests directly upon the masonry forming the water-table.

The staff of workmen consisted of a superintendent, a master mason, who mixed the mortar, two divers, and five boatmen and laborers. They had a barge and three small boats. The barge was used entirely for the divers, and carried the air-pump One of the boats was used for making the mortar and lowering the materials; the other two were used to ply between the barge and the first boat and the shore, one for carrying materials and the other for the workmen.

The mortar used in the sacks, as well as that for the masonry, was composed of equal parts in volume of sand and cement. The sacks were made by cutting the ordinary cement bags in three. They were therefore about 12 in. in diameter and 16 in. long. They were used altogether for four piers about 150 cub. ft. in the sacks and 1,980 cub. ft. of masonry, containing on an average one-third stone blocks for two-thirds of cement. The cost per cubic meter amounted to about 95 fr., including therein all the preliminary expenses, such as the clearing of the foundations, the building of screens and coffer-dams with the loss of time and damage occasioned by floods.

When the work proceeded steadily they were able to make about 3 cub. m. (107 cub. ft.) of masonry a day, the cost being divided as follows: Labor, 75 fr.; use of boats, etc., 5 50 fr.; material, 56 fr.; a total of 137.50 fr., being nearly 46 fr. per cubic meter, or 25.1 cts. per cubic foot.

Really, in consequence of some losses of mortar, not quite 3 cub. m. a day of masonry were obtained, and it is probable that the cost per cubic meter was a little higher than that given, but it did not exceed 50 fr., or 27.3 cts. per cubic foot. In the total cost given above of 95 fr., it therefore appears that about 52.6 per cent. was the cost of

the masonry itself, and the remaining 47.4 per cent. was that of the other expenses.

As to the sacks of cement rammed down in the excavations, it was possible to use only about 1 cub. m. a day, the cost being for labor, 76 fr.; for use of boats, etc., 5.50, and for material, 43.50 fr.; a total of 135 fr., or about 73.4 cts. per cubic foot.

The work lasted about 66 days—from June 1 to August 10—in spite of three or four interruptions, one of which lasted 10 days, being occasioned by a heavy freshet.

Masonry built under water by a diver can be employed with advantage to repair foundations where only a small amount of masonry is required, and where it can be founded either upon hard bottom or old masonry. The application of this process requires only a small plant, and does not require navigation to be obstructed, and while it cannot be claimed that masonry thus built is quite equal to that built in the open air, it can at least be said that it gives results much better than with concrete made under water.

The use under water of sacks of cement mortar appears also in certain cases to be capable of an excellent application. It is probable that no other process will permit work under water to be repaired which will secure so perfect a contact with old masonry.

Another example may be cited in which the use of sacks of cement has rendered real service. The viaduct which is now being built across the Loire for the railroad from Bourges to Gien has the foundations of the piers in pits, which are dug through a water-bearing sand to the marly limestone which forms the subsoil of the valley. In some of these excavations the bottom is disturbed by violent currents of water coming either from the water-bearing sand into the pit, or from cracks, which are frequently met with in the limestone, and the waters of which spout out in the bottom of the excavation. This water could not be carried away by masonry channels or drains since the mortar would be at once washed out. The use of cement in sacks allows the engineers to obtain a pavement or foundation for the bottom of the pit almost solid and fitting itself perfectly to all the irregularities of the bottom, thus allowing the concrete to be set with perfect security.

It sometimes happened that the quantity of water is so great and the points to be attended to so numerous, that it is impossible to carry off the water in drains. Besides it was found necessary to cut down the little stumps which are found thickly scattered in the ground in that neighborhood, and these were covered with water. It would be possible, it is true, in such a case to make a ring of dry masonry and set concrete within it, but this ring of masonry would rest upon the ground very unevenly and would not fill properly the gaps remaining between the stumps. With sacks of mortar, on the other hand, there could be formed in the submerged excavations a foundation perfectly fitted to the bottom and surrounding the beds of the stumps up to the surface of the water. The water could be allowed to pass out by a series of channels which could be made in placing the sacks, and the concrete could be set on top of it without fearing that it would be washed away.

For this purpose the mortar must have a different composition from that adopted at Joigny. The quantity to be employed in a given time is too great to proceed by mixing small quantities. Mortar would then be made in large quantity, and, as a certain time is needed to place it in sacks and carry it to place, it was necessary to use a slower setting cement. For that purpose there was used a mortar the proportions of which were 450 kg. of Vassy cement; 150 kg. of Theil chalk and 1 cub. m. of sand. It can be said from experience gained in conditions entirely similar to those of the work executed at the bottom of the pits, that the cement will not be sensibly washed away. There were placed in a trench, in the line of flood of the water where the current was quite strong, sacks which the workmen had shaped upon one another by stamping them down, forming conduits to the interior of the body thus formed, and which were filled entirely with stones. The sacks taken out after a certain time were perfectly formed one upon another. In those which were compressed on all faces the mortar had not suffered the least washing out. In those forming the channels the mortar on the side toward the channel was very slightly washed away, but this result was altogether superficial, and did not affect the solidity of the cement inside.

Moreover, in December, 1888, a certain number of sacks was rammed down in the bottom of the excavation in a rocky cavity, from which the water came out with considerable force. This excavation was abandoned during the winter and the work resumed in the month of April, 1889, when it was found that although the sacks had been driven down in the middle of a spring of water, the cement had set perfectly without being washed away, and most of the sacks were so well set into the holes and irregularities that it would be impossible to remove them. It can then be concluded from those trials that the sacks of cement, the usefulness of which has already been approved for repairs to foundations, can also be very conveniently employed at the bottom of excavations traversed by currents of water to make channels or even surfaces, under which the water can be completely covered in such a way as to permit the concrete or foundation masonry to be set dry.

It may, however, be remarked in a general way that if the use of mortar in sacks allows us to avoid completely the washing away under the most unfavorable circumstances, the interposition of the cloth of the sack has at the same time the effect of preventing the adherence of the different parts of this sort of masonry. Under pressure the cloth will only allow the escape of a little matter, which does not make a joint. It consists, therefore, in fact, of only dry masonry, but it is dry masonry presenting this advantage, that the joints are infinitely small in consequence of the facility with which the sacks can be made to take different shapes.

This absence of adherence of the different parts has, moreover, no inconveniences under the circumstances in which it has been used. At the Bridge of Joigny it is in fact completely covered by the masonry. At the viaduct of Gien it is found at the bottom of the excavations in a valley which is only covered at the highest floods of the Loire and at such depths that injury is not to be feared.

It is believed that in similar cases the use of sacks of cement may render real service, and it is for this reason that it has been considered interesting to give details of the applications which have been made of this process.

AERIAL NAVIGATION.

By O. Chanute, C.E., of Chicago.

(A lecture to the students of Sibley College, Cornell University; delivered May 2, 1890.)

(*Continued from page 367.*)

POSSIBLE IMPROVEMENTS IN BALLOONS.

Before expressing an opinion upon the future speed of navigable balloons it may be interesting to review the various difficulties which have hitherto been met, and to inquire into what patent attorneys call "the state of the art."

The greatest speed thus far attained has been 14 miles per hour, which, as indicated at the beginning, is insufficient to cope with most of prevailing winds, particularly at sailing heights above the ground, and the following difficulties have been encountered and, to a certain extent, overcome.

1. Excessive loss of gas in early experiments.

This has been remedied by closer tissue of envelope and better varnishes, as well as by regulating valves, so that the loss of gas at the captive balloon in Paris last summer was said to average less than 2 per cent. per day.

2. Resistance of air to forward motion.

This has been largely diminished by pointed ends, but much remains to be done in ascertaining the best proportions.

3. Need of a propeller to act on the air.

This has been measurably solved by the aerial screw, which is said to exert from 50 to 70 per cent. of the power applied, but is yet less efficient than the marine screw, which works up to 84 per cent.

4. Need of steering gear.

This has been fairly worked out by various arrangements of rudders and keel cloths, which have given command of the apparatus when in motion.

5. Need of a light motor.

This is the great difficulty. Steam has been tried with a weight of 154 lbs. per H. P., including fuel and water, and electric engines with a weight of 130 lbs. per H. P. Neither are sufficiently light to give the necessary speed, except, as will be explained, for very large apparatus.

6. Need of endwise stiffness.

This has been remedied by compressing the gas inside the balloon, either through the use of a loaded safety valve or through the use of an internal air bag. As speed increases more will needs be done in this direction, and this will require stronger and heavier envelopes for the gas bag.

7. Need to prevent deviations in course.

This has been overcome by placing the screw in front, where it is more effective than behind.

8. Need of longitudinal stability.

This has only been partly solved by various methods of suspension. There is still a tendency to pitch when meeting gusts of air, and this will increase when greater speeds are attained. It will need to be worked out by experiment.

9. Need of altitudinal stability.

This is the tendency of the balloon to rise or fall with the heating or cooling of the gas. It has been met in only a crude way by alternately discharging either gas, to prevent the balloon from bursting, or ballast, to prevent it from coming down. This rapidly exhausts both gas and ballast, and limits the time of the trip.

It has been repeatedly proposed to substitute for this method a vertical screw, to raise and depress the balloon, which should then be at starting slightly heavier than the air which it displaces; and one of the best proposals for this purpose is due to an American engineer, Mr. E. Falconnet, who patented it in 1885, together with many other features, to remedy the various difficulties which have been encountered; but death cut short his labors, and his devices have never been experimented on.

The great desideratum is to gain increased speed, and there are at least four ways by which this may be accomplished.

1. By giving the balloon a better form of hull, so as to diminish the resistance. *La France* was rather blunt in front, and there is reason to believe that by simply moving the largest section further back, increased speed will result.

2. By designing a more efficient aerial screw. Commandant Renard has been experimenting in this direction, and says there is a shape much better than others, and that this form cannot be departed from without getting very bad screws; falling, as he expresses it, into a veritable precipice on either side.

3. By devising a lighter motor, in proportion to its energy. This is the great field in which work remains to be done. It was announced in September, 1888, by a newspaper correspondent that Commandant Renard had built a motor weighing 1,100 lbs. and developing 50 H. P., but since then nothing has been heard of it.

4. By simply building larger air-ships, for, inasmuch as their contents, and consequent lifting power, will increase as the cube of their dimensions, while their weight will, approximately, only increase as the square, the surplus lifting power will evidently increase with the size, and greater motive power in proportion can be used.

Let us suppose, for the sake of this argument, that no improvement whatever has been achieved in either of the first three ways which have been mentioned, and inquire simply what would be the effect of doubling the dimensions of *La France*. The comparison will be approximately as follows:

Principal Dimensions.	*La France.*	Double Size.
Length, out to out.................... ft.	165	330
Diameter, largest section................ "	27.5	55
Contents of gas....................cub. ft.	65,836	526,688
Lifting power..........................lbs.	4 402	35,216
Weight of apparatus-............... ... "	2,451	9,804
" Cargo and aeronauts.......... "	779	1,500
" Machinery .... "	1,174	23,912

As the motor (dynamo and battery) of *La France* weighed 130 lbs. per H. P., we have for that of double the size $\frac{23,912}{130} = 182$ H. P. motor, and calculating the speed by the formula of Commandant Renard, and inserting the new diameter, 16.8 meters, we have:

$$T = 0.0326 \times \overline{16.8}^2 \times V^3 \text{ in kilogrammeters.}$$

But as we have 182 H. P., and there are 75 kilogrammeters in the H. P., we have further:

$$182 \times 75 = 0.0326 \times \overline{16.8}^2 \times V^3,$$

$$\text{whence } V = \sqrt[3]{\frac{13650}{9.2}} = 11.2 \text{ meters.}$$

So that we see that the speed of the new air-ship will be 11.20 meters, or 36.7 ft. per second, say 25 miles per hour.

The same result is arrived at by considering that the new balloon will require four times the motive power of *La France* to go at the *same speed*, and that the power required increases as the cube of the speed. So that we see that a speed of 25 miles per hour is even now in sight, without any other improvement than doubling the size of the balloon.

It will not be safe to assume, however, that increased speed can be indefinitely obtained with mere increase of size, because with more speed a series of new difficulties are likely to arise, and some of the old ones to be aggravated.

The first of these will probably come from the lack of longitudinal stiffness. Although it has been found that a certain amount of internal gas pressure gives the elongated balloon sufficient rigidity to resist the pressures due to low speeds, so soon as these are increased there may be a tendency to buckle, twist and collapse, and this means more pressure, a stronger envelope and more weight; or a rigid internal frame, as proposed by Mr. Falconnet; and this also means much more weight.

Next, there will be in great balloons much greater difficulty in distributing equally the weight of the car and its contained motor over the gas-bag, because of the necessary greater concentration of weight in the car. It will besides be found more difficult to apply the propelling power near the line of equilibrium, so as to avoid oscillations.

There will also be increased difficulty from the flow of the gas back and forth inside of the elongated balloon, thus displacing its center of gravity, and threatening the danger which so nearly proved fatal to Giffard. Moreover, even slight changes of outer temperature, heating and cooling the gas in the balloon, and thus charging its ascending power, are likely to be far more troublesome when operating on large than on small masses of gas, so that it seems likely that large balloons will be found more unstable, both vertically and logitudinally, than the comparatively moderate sizes which have so far been experimented upon.

These difficulties can all be surmounted, no doubt, including the remaining one that large balloons will be costly, and that few can afford to experiment with them; but the various appliances necessary for stability will involve more weight, and this again will require more size.

Be this as it may, it is evident that somewhere a limit will be reached beyond which unmanageable sizes will be met with. The weight, the size, the resistance will increase, as well as the speed, and somewhere there will be impracticability. We have seen that to go 25 miles per hour, and thus brave the wind about three-quarters of the time, we need an elongated balloon similar in shape to *La France*, 330 ft. long and 55 ft. in diameter. It is probable that, by improvement in the first three ways which have been mentioned, it may attain a speed of 30 or 35 miles per hour; but when it is attempted to obtain 40 miles per hour out of it it will grow to lengths of, say, 1,000 ft., or as long as four ordinary city blocks, and diameters of 150 ft., or the height of an ordinary church steeple.

These seem unmanageable and impracticable sizes for ordinary uses. They are greater than those of ocean steamers, because the speed required is greater, to overcome the

aerial currents; and the care and maintenance of these great air-ships will be a difficult matter.

It seems likely, therefore, that in the near future elongated balloons will be built which will be driven at 25 or 30 or a few more miles per hour, which will be able to sail about on all but stormy days; but the cargoes carried in proportion to the size will be small, and to obtain speeds similar to those of express trains some other form of apparatus will have to be sought for.

(TO BE CONTINUED.)

THE SECOND SECTION OF THE GREAT SIBERIAN RAILROAD.*

By A. ZDZIARSKI, ENGINEER.

THE second link in the Great Siberian Railroad is the Oufa Zlatooust Railroad, which is 200 miles in length, traversing the secondary ranges of the Oural Mountains and crossing many mountain streams. The location was begun in the summer of 1886, and was very interesting work on account of the many difficulties met with. It required much time and money, and was completed finally not without some faults, especially on the first section of 20 miles, where the crossing of the divide between the White River and the Oufa may be considered obviously superfluous.

In addition to the fact that this line is part of the great through road, it was important on account of the development of the local mining industry, which has hitherto been very slow.

The preliminary exploration was made in 1884 by a commission including representatives of the departments of Internal Communication, of Finance and of Crown Domains. The final location, however, was made from surveys completed in 1886 and 1887, and was immediately followed by the construction, which began in 1888. According to this location the line starts from the Oufa station of the Samara-Oufa Railroad and runs down the right bank of the White or Bielaia River, crossing a very broken country. It is here generally a hill-side line with heavy rock cutting and high fills, and as the soil is intersected by layers of gypsum, there were enormous shrinkages in these fills. The line then rises to the divide between the White and the Oufa Rivers and descends into the valley of the latter river, crossing it with a long iron bridge having three spans of 350 ft. each. After crossing the Oufa the line follows the left bank of that river, then turns up the valley of its tributary, the Lobau, and crosses the divide into the valley of the Sim. Crossing this river it follows its right bank to Lake Miniar, near the Miniar Iron Works, and ascends the valley of the Eralka River until it reaches the divide between the Sim and the Urezan, crosses this and then follows the valleys of the Little and Great Berdiash successively, until it reaches the main stream of the Urezan, which it crosses by a bridge of 280 ft. span, and then follows to the mouth of the Vrazow-Kluch; then ascends the valley of that stream nearly to its head and crosses another divide into the valley of the I. After crossing that river it descends the Tluar, a tributary, and following the slopes of a secondary divide between the I and its tributary, the Great Satka, it crosses the Koukish, Baldauk and Suleia mountain ranges and descends into the Great Satka Valley, crossing that stream to the Berdiash again and descending another divide between the Satka and the I. Descending the Valley of the Tainak and crossing the Kauvash it again reaches the valley of the I, which it follows to Zlatooust.

From this description and from the map and profile accompanying, it is evident that the location was not an easy one. It crosses many divides and some very rapid rivers, and these difficulties have made the length of the line 200 miles, when the distance from Oufa to Zlatooust in a direct line is only 144 miles.

Four of the rivers crossed—the Oufa, the Sim, the Urezan and the Satka—are navigable in spring, and the bridges crossing them had to be designed for a proper elevation above high-water level.

* See article on the First Section of the Great Siberian Railroad, in the JOURNAL for June, 1890, page 258.

The longest distance between stations is 17 miles; assuming the speed of passenger trains at 20 miles and of freight trains 13½ miles an hour, this would allow two passenger and seven freight trains daily each way without delays.

The maximum grade going westward is 0.85 per cent. and going eastward 1 per cent. The minimum radius of curvature is 1,050 ft., which is somewhat less than on the Samara-Oufa Line.

The cross section of the grade, designed for single track, has a width of 18.2 ft., and is everywhere in the river valleys elevated at least 3.5 ft. above high water. The total quantity of earthwork required is 18,000,000 cub. yds., which is an average of 90,000 cub. yds. per mile. The distribution of this earthwork varies very much, the most difficult portions being the crossing of the divide between the Oufa and the White River, 3.5 miles, where the average rises to 328,700 cub. yds. per mile; the crossing of the Oufa, two miles, about 760,000 cub. yds.; the crossing of the Sim, 1½ miles, about 580,000 cub. yds., and the crossing of the divide between the Urezan and the I River, 1½ miles, where about 570,000 cub. yds. had to be moved. The nature of the soil varies very much, but is generally difficult. Rock and stone cuts amount to about 252,000 cub. yds. The highest fill is 94½ ft. and the deepest cut 68 ft. At a number of points retaining walls are required, amounting in all to about 67,300 cub. yds. of masonry.

As might be expected from the nature of the line, many bridges are required, which may be briefly described as follows:

1. Bridge over the Oufa River 1,050 ft. in length, divided into three spans of 350 ft. each. This bridge is of the same type as the bridge over the White or Bielaia River—that is, a through truss of semi-parabolic system with double intersections.
2. Two bridges of 280 ft. span, one a through bridge over the Sim River of very similar type to the above, the other a deck span, with semi-parabolic lower chord, over the Urezan.
3. Two bridges each of 210 ft. span over the Katav and the Sim rivers.
4. Two bridges of 175 ft. span over the Sim River.
5. A bridge over the Miniar River of 105 ft. span.
6. Iron girders on stone abutments, with spans varying from 14 to 56 ft. in all, 110 in number.
7. Iron girders on stone abutments of 7 ft. span, 85 in number.
8. Wooden bridges with stone abutments, four in number, of 3½ ft. span.
9. Of stone arched culverts there are 94, with spans varying from 3½ to 21 ft.

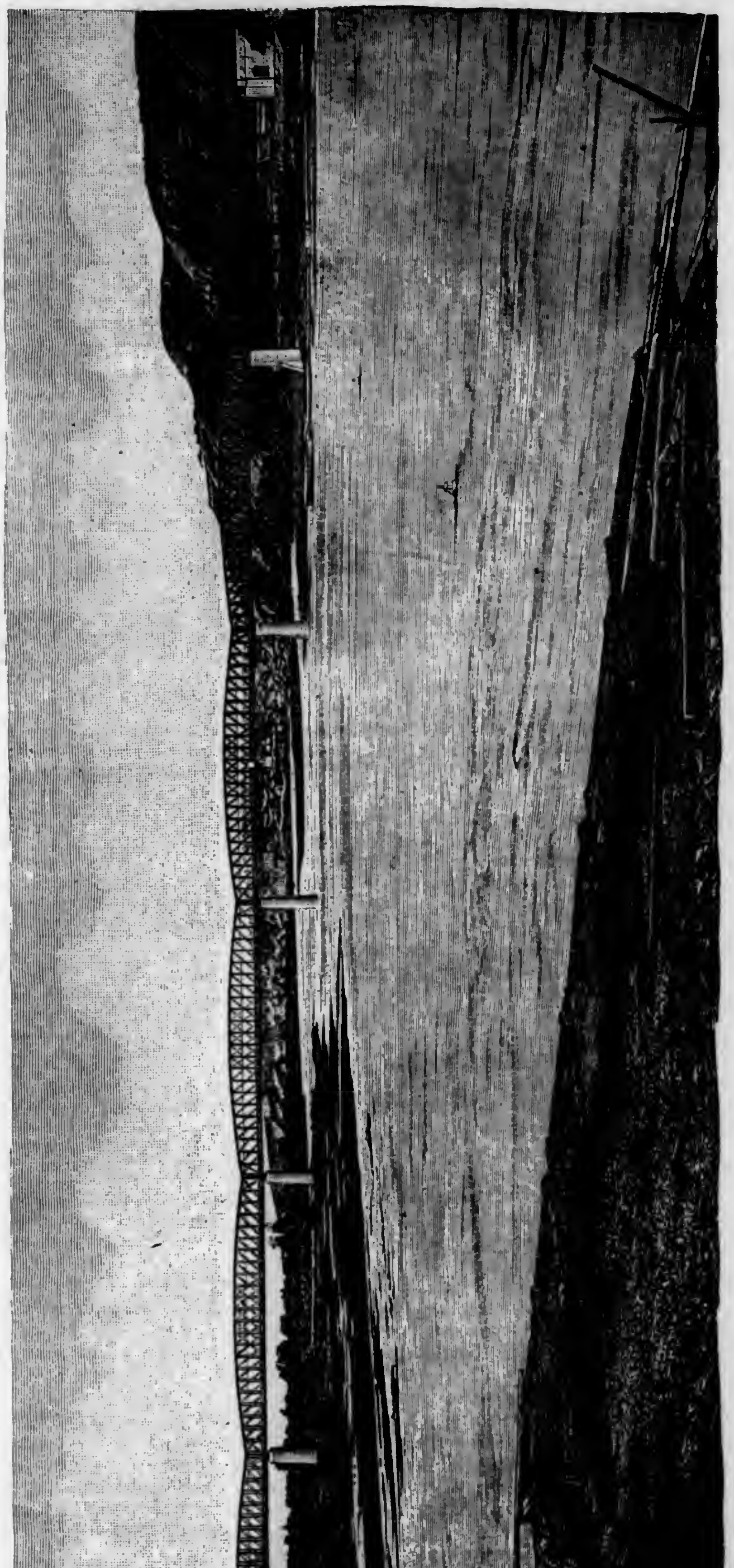
The masonry on the line is made partly with cement mortar and partly with compound hydraulic mortar.

The Oufa Bridge has a clear elevation of 34½ ft. above high-water level. The foundations of the piers and abutments of this bridge rest on six caissons sunk to a depth of 66 ft. below low-water level.

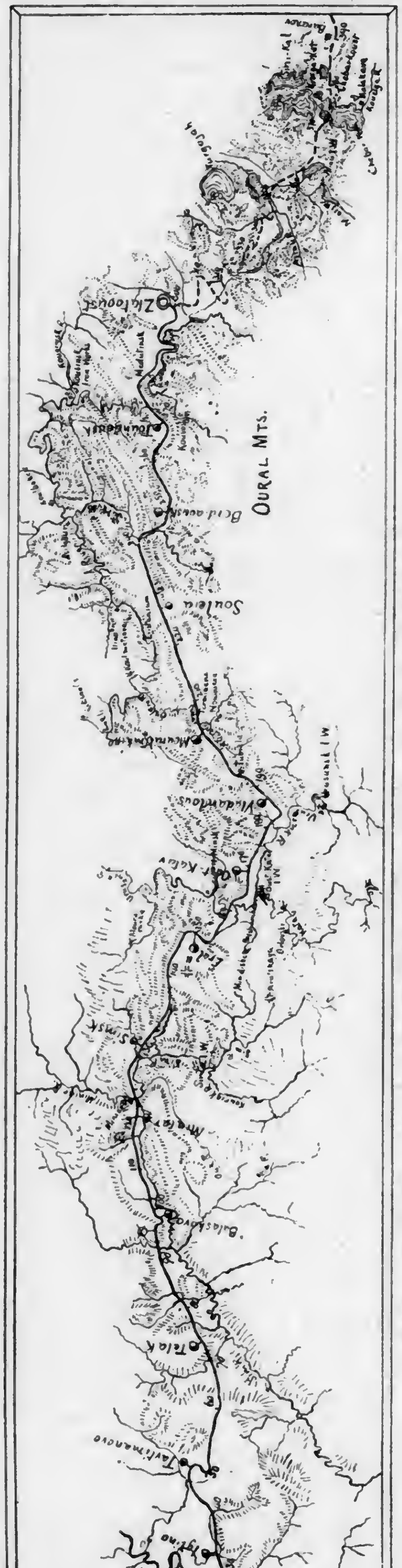
The track presents no peculiarities, but is of the same type as that of the Samara-Oufa Line. The rails are of steel, of two patterns, weighing respectively 65½ lbs. and 58⅝ lbs. to the yard. They are made in one of the Oural iron mills, the Katav-Ivanov Works.

As on the Samara-Oufa Line, and according to the system of track repairs generally adopted in Russia, section houses are provided at each station, and at such intermediate points as are necessary, the average distance between them being 9 miles. In all there are 51 of such houses of different sizes, and besides these 82 small houses are provided for track watchmen. All of these buildings are of wood on stone foundations.

Including the Oufa station there are 17 stations on the line. The greatest distance between them is 16½ and the smallest 7 miles. All of these stations are of wood, on stone foundations, with iron roofs. Their area varies from 1,000 to 3,200 sq. ft. The terminal station at Zlatooust covers an area of 4,900 sq. ft. The country traversed by the road is very thinly inhabited, and it was necessary to provide houses for all the officers and employés. These are generally of a simple type, of wood. There are three engine-houses, one at Asha holding four engines, one at



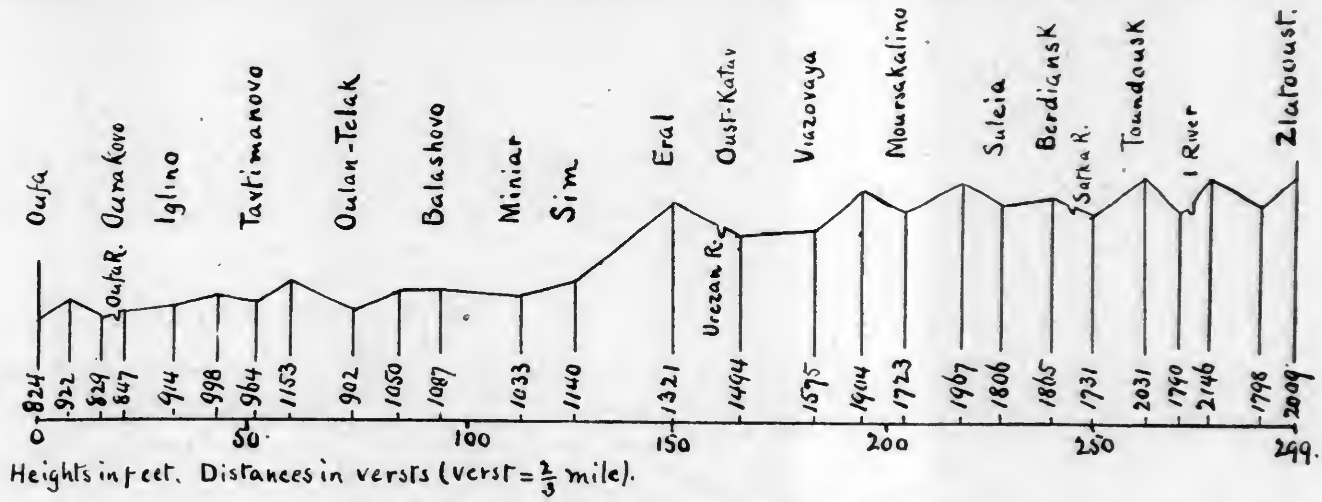
BRIDGE OVER THE BIELAIA RIVER ON THE SAMARA-OUFA RAILROAD, RUSSIA.



MAP OF OUFA-ZLATOOUST RAILROAD, AND CHELABINSK EXTENSION.

SECOND SECTION OF THE GREAT SIBERIAN RAILROAD.

Viazovaia for six engines, and one at Zlatooust, also for six engines. No repair shops are provided, as it is expected



PROFILE OF OUFA-ZLATOOUST RAILROAD.

that all general repairs will be made at the Oufa shops, built for the Samara-Oufa Railroad, which will be enlarged if necessary. The engine-houses are either of stone or brick with iron roofs. As it was difficult to estimate the traffic of the new line, no freight stations or storehouses have been built, but they will be constructed after the road is opened, when it will probably be easier to ascertain the needs of the traffic.

At every station there is water supply provided. At the way stations provision is made for a supply of at least 4,800 cub. ft. daily, and at the stations where there are engine-houses 9,600 cub. ft. daily. The water-tanks, which hold 2,788 cub. ft., are of iron, placed on stone buildings with an upper story of wood covering the tank.

In providing the equipment it was calculated that one passenger and two freight trains would be run in each direction every day, with an average of four working trains per week and of an officer's train every month. On this estimated mileage, with an allowance of 20 per cent. for switching, there will be a total engine mileage of 17,360 miles for passenger engines and 33,600 miles for freight engines monthly. In Russia it is usually assumed that a six-wheel or passenger engine will run 1,466 miles and an eight-wheel or freight engine 1,333 miles per month. On this basis 11 six-wheel and 24 eight-wheel engines will be provided. These will be of the ordinary type in use in Russia.

The car supply will include 42 passenger cars and 410 freight cars. One-fifth of the total number of freight cars will be provided with brakes. In calculating the car supply the average effective speed of passenger trains is assumed at 17 miles and the freight trains at 8 miles per hour.

In the construction of this line the work was divided into sections of from 10 to 20 miles in length and also according to the description of work. These sections were let to sub-contractors, the prices being based on the unit of work.

The accompanying map shows the line as built from Oufa to Zlatooust. The dotted line beyond the last-named point shows the more difficult part of the extension from Zlatooust to Chelabinsk, work on which is to be begun this year. The other cut shows the profile of the Oufa-Zlatooust Line.

The Oufa Bridge alone cost 300,000 roubles, or more than one-fourth of the total amount charged to bridges. Amounts which are given in roubles are not converted into American currency for the reasons stated in the previous article—the varying exchange value of the rouble, which we may say is generally assumed at about 60 cents, and the fact that owing to the lower price of labor in Russia the purchasing power of the rouble in work is very nearly equal to that of a dollar in America.

Work on the construction of the Oufa-Zlatooust Railroad was begun in the fall of 1889; about halt of the earthwork and masonry was finished in 1888; the remaining half of the earthwork and masonry in 1889, and in addition the iron superstructure of the bridges, most of the bridge erection and about half the tracklaying. The remainder of the tracklaying and the buildings are now in progress, and the line will be open to Zlatooust in the fall of this year.

The cost of the line from Oufa to Zlatooust is calculated as follows:

	Description of Work.	Cost in Roubles. Total.	Cost in Roubles. Per Mile.	Per Cent. of Total.
1	Expropriation, lands, etc.	211,073	1,055	1.04
2	Earthwork	5,890,452	29,452	29.13
3	Bridges	5,023,592	25,118	24.85
4	Track and ballast	4,009,013	20,045	19.84
5	Road accessories	56,681	283	0.28
6	Telegraph	70,563	353	0.35
7	Road buildings and crossings	250,320	1,252	1.24
8	Station buildings	864,084	4,321	4.27
9	Water supply	257,839	1,289	1.28
10	Station accessories	308,250	1,541	1.53
11	Rolling stock	1,608,868	8,044	7.96
12	Branch to Zlatoousi Iron Works	10,000	50	0.05
13	General expenses	1,285,536	6,428	6.37
14	Extraordinary expenses	109,558	548	0.54
15	Controlling and police	117,426	587	0.54
16	Sundry works	147,408	737	0.73
	Total	20,220,663	101,103	100.00

The illustration given herewith is a general view of the great bridge over the Bielaia (White) River on the Samara-Oufa line, which was described in the June number of the JOURNAL. This bridge has six spans of 350 ft. each; the piers and abutments are founded on caissons sunk by pneumatic process. The foundation for the piers is 56 ft. below the low-water level, and the foundations of the abutments are respectively 42 and 49 ft. below low-water level. The masonry is of limestone, the up-stream faces of the piers and the ice-breakers being of sandstone. The superstructure was designed by Professor N. A. Beleloubski, and is a through truss of semi-parabolic system with double intersections, somewhat resembling the Linville truss. The chords are of channel shape. The posts are made of four or more separate angle-bars placed at such a distance apart that the floor-beams could be fixed between them. The chief feature of this bridge is that the floor-beams are not riveted to the lower chord, but are carried on special hinges or links, so that the strain from the floor-beams is transmitted to the center of the chord, avoiding all torsional strains of the channel-bars, and therefore the strain on the lower chord is much less. This

system of hanging the floor-beams requires separate cross-girders to connect the lower chords.

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C.E.

(*Continued from page* 361.)

CHAPTER XXVII.

HOWE TRUSS BRIDGES.

The plans presented in Plates 116, 117 and 118 are for a Howe truss through bridge of 66 ft. span. Plate 116 shows the general plan; Plate 117 a number of the details, and Plate 118 the remaining details and the strain-sheet. The bill of materials—No. 47—is given herewith, and will, with the drawings, give sufficient information to enable the engineer to construct the bridge.

No. 47. Bill of Material for Howe Truss Bridge, Through Span, 66 Ft. Plates 116, 117 and 118.

Timber.

No. of Pieces.	Description.	Size.	Length.	Ft. Board M's're.	Kind of Wood.
4	Top Chord......	6 in. × 12 in.	33 ft. 0¾ in.	793	Yellow Pine.
4	" "	6 in. × 12 in.	15 ft. 0¾ in.	360	" "
2	" "	8 in. × 12 in.	26 ft. 0½ in.	418	" "
2	" "	8 in. × 12 in.	22 ft. 0½ in.	353	" "
4	Bottom Chord..	6 in. × 14 in.	40 ft. 0 in.	1,120	" "
4	" " ..	6 in. × 14 in.	32 ft. 0 in.	896	" "
4	" " ..	8 in. × 14 in.	20 ft. 0 in.	747	" "
2	" " ..	8 in. × 14 in.	32 ft. 0 in.	597	" "
8	Braces	12 in. × 10 in.	25 ft. 9¼ in.	2,064	" "
8	"	10 in. × 8 in	25 ft. 9¼ in.	1,384	" "
8	"	9 in. × 8 in.	25 ft. 9¼ in.	1,240	" "
8	Counters.......	9 in. × 7 in.	25 ft. 9¼ in.	1,080	" "
4	"	9 in. × 7 in.	13 ft. 0 in.	277	" "
6	Laterals........	6 in. × 8 in.	19 ft. 1½ in.	459	" "
10	"	8 in. × 8 in.	19 ft. 1½ in.	1,020	" "
2	"	6 in. × 8 in.	13 ft. 11¼ in.	112	" "
2	"	8 in. × 8 in.	13 ft. 11¼ in.	150	" "
8	Bolsters........	6 in. × 12 in.	9 ft. 0 in.	432	" "
4	"	8 in. × 12 in.	9 ft. 0 in.	288	" "
8	Bridge-seats....	6 in. × 12 in.	6 ft. 0 in.	288	" "
4	" "	8 in. × 12 in.	6 ft. 0 in.	192	" "
4	Sills.	12 in. × 12 in.	18 ft. 0 in.	864	Spruce or Pine.
20	Floor-beams	9 in. × 16 in.	18 ft. 0 in.	4,320	" " "
6	Stringers.......	6 in. × 12 in.	72 ft. 0 in.	2,592	" " "
62	Ties............	8 in. × 8 in.	12 ft. 0 in.	....	Oak.
2	Guards.........	6 in. × 6 in.	72 ft. 0 in.	532	Spruce or Pine.
4	Plank..........	2 in. × 8 in	72 ft. 0 in.	384	" " "
8	Blocks........	2 in. × 8 in.	2 ft. 0 in.	24	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2¾ in.	26 ft. 10 in.	12	Bolster b'lts	1¼ in.	3 ft. 4 in.
8	"	2½ in.	26 ft. 10 in.	20	Fl.beam b'ts	1¼ in.	4 ft. 4 in.
4	"	1¾ in.	26 ft. 10 in.	48	String'rb'lts	¾ in.	2 ft. 6 in.
6	Laterals	1½ in.	18 ft. 6 in.	28	Tie-bolts.	¾ in.	2 ft. 6 in.
4	" ...	1¾ in.	18 ft. 6 in.	28	G'rd-r'l-blts	¾ in.	1 ft. 3 in.
156	Chord-bolts.	¾ in.	2 ft. 0½ in.	24	Spikes......	½ in.	9 in.
20	Brace-bolts.	¾ in.	2 ft. 0½ in.				
12	" "	1¼ in.	2 ft. 4 in.				

Other Iron Work.

Washers: 10 of pattern *H*1; 68 of *H*2; 425 of *G*.

Castings: 20 of pattern *A*; 4 of *B*; 16 of *C*; 8 of *D*; 20 of *E*; 4 of *F*; 12 of *I*; 16 of *J*; 56 of *K*; 68 of *L*; 24 of *M*; 6 of *N*; 12 of *O*.

As it may appear that there is some repetition of details in these plans, it may be well to say here that the intention in giving these designs is to have each one complete in itself, so that, if desired, it may be used without reference to any of the others. Necessarily some of the details—patterns, washers, etc.—will be the same for different spans, and must thus be repeated or duplicated in different plates.

It may also be well to note here once more that in studying or using these plans the reader will perhaps find it convenient to refer back to the general remarks on Howe truss bridges, in Chapter XXII, which was published in the Journal for March, 1890, beginning on page 128.

(TO BE CONTINUED.)

RAILROADS IN BOLIVIA.

The Republic of Bolivia in South America has heretofore been without railroads, but now proposes to build several, under a law passed about the end of 1889. The first line to be built is to run from Oruro southward to Ascotan and thence to the Chilian frontier, where it will connect with the Antofogasta Railroad, now under construction in Chili; this is to be completed by January 1, 1892.

A second line is to run from La Paz to the Peruvian frontier. A third will connect Sucre with Oruro and La Paz, and a fourth will extend from Sucre southward to the Argentine frontier.

Other lines proposed are from Sucre eastward to the Paraguay River and from Tarija in the same direction. Lines from Sucre and La Paz northward are also spoken of, but will be the last to be built. Surveys for these lines are still to be made, but no great difficulties are expected, as they will traverse the more level portion of the great elevated plain which forms the larger part of Bolivia.

The law authorizing the construction of railroads provides for a guarantee of 6 per cent. interest on the capital invested in the lines designated by the Government. The stockholders are to have the option of accepting a grant of one square league of land for each league of railroad built, instead of the guarantee of interest.

THE WORKS AT THE KHOJAK TUNNEL.

Reference has before been made to the tunnel by which the Indian Frontier Railroad is to cross the summit at the Khojak Pass in the Himalaya Mountains on its way to Kandahar. The headings in this tunnel, which is 12,600 ft. long, were recently joined. The following account of the actual condition of the tunnel, and the description of the temporary line in use over the Khojak Pass, are given by *Indian Engineering*.

An idea seems to be prevalent that now that the Khojak Tunnel headings have joined, trains will forthwith be able to run through to New Chaman. This is far from being the case; there is still more than half the enlargement to full section to be done, and throughout the whole of this a masonry arch lining will require to be turned, so that fully a year must elapse before there is any prospect of through running being possible.

Meanwhile, the traffic is being carried on by means of temporary lines laid over the hill, and as these exhibit several features of interest, owing to their severity of grade and diversity of system, we publish herewith a drawing showing the whole of them in profile.

When the three rival projects for the passage of the Kwaja-Amran Range were under consideration, it was at first regarded as an objection to the route finally selected that the tunnel, which formed its chief feature, would take from two to three years to construct, and the Government of India considered that it was of paramount importance to establish communication across the range at a considerably earlier date, as in the event of complications again arising in Central Asia a forward movement of troops might be necessary.

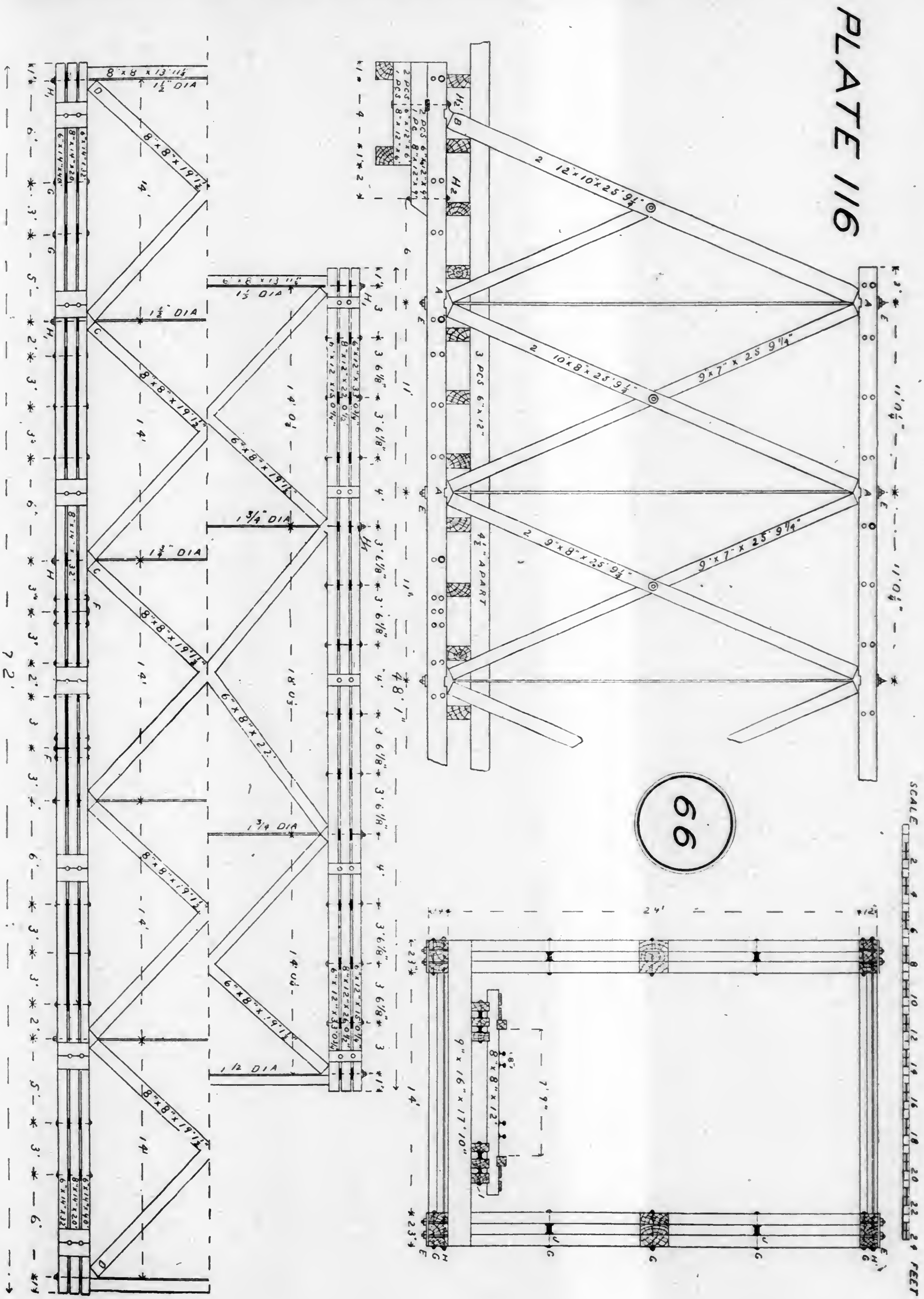


PLATE 116
66
SCALE
FEET

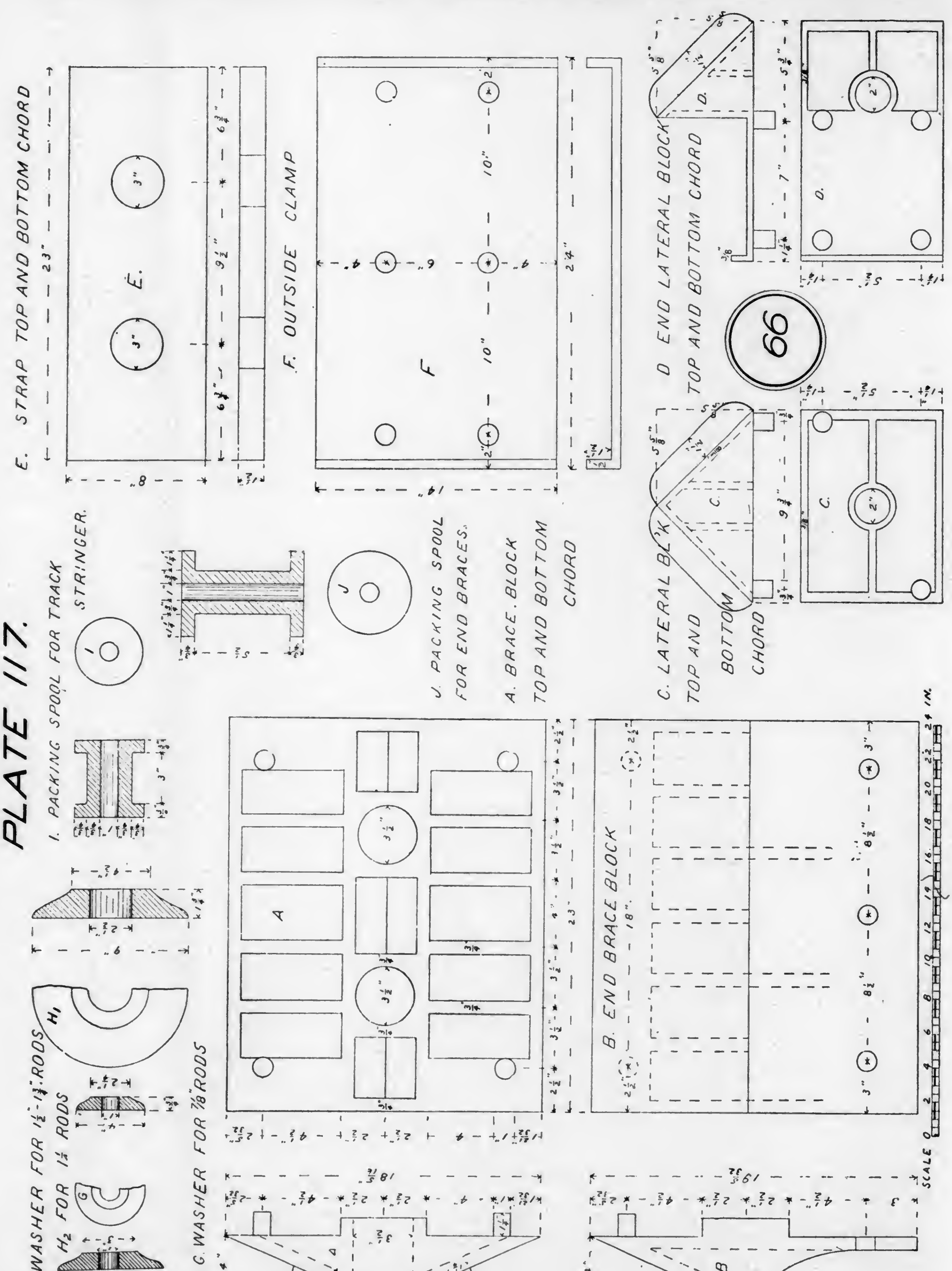


PLATE 117.
I. PACKING SPOOL FOR TRACK STRINGER.
J. PACKING SPOOL FOR END BRACES.
A. BRACE. BLOCK TOP AND BOTTOM CHORD
E. STRAP TOP AND BOTTOM CHORD
F. OUTSIDE CLAMP
D END LATERAL BLOCK TOP AND BOTTOM CHORD
C. LATERAL BL'K TOP AND BOTTOM CHORD
B. END BRACE BLOCK
H, WASHER FOR 1½"-1¾" RODS
H2 FOR 1¼ RODS
G. WASHER FOR 7/8" RODS
66
SCALE

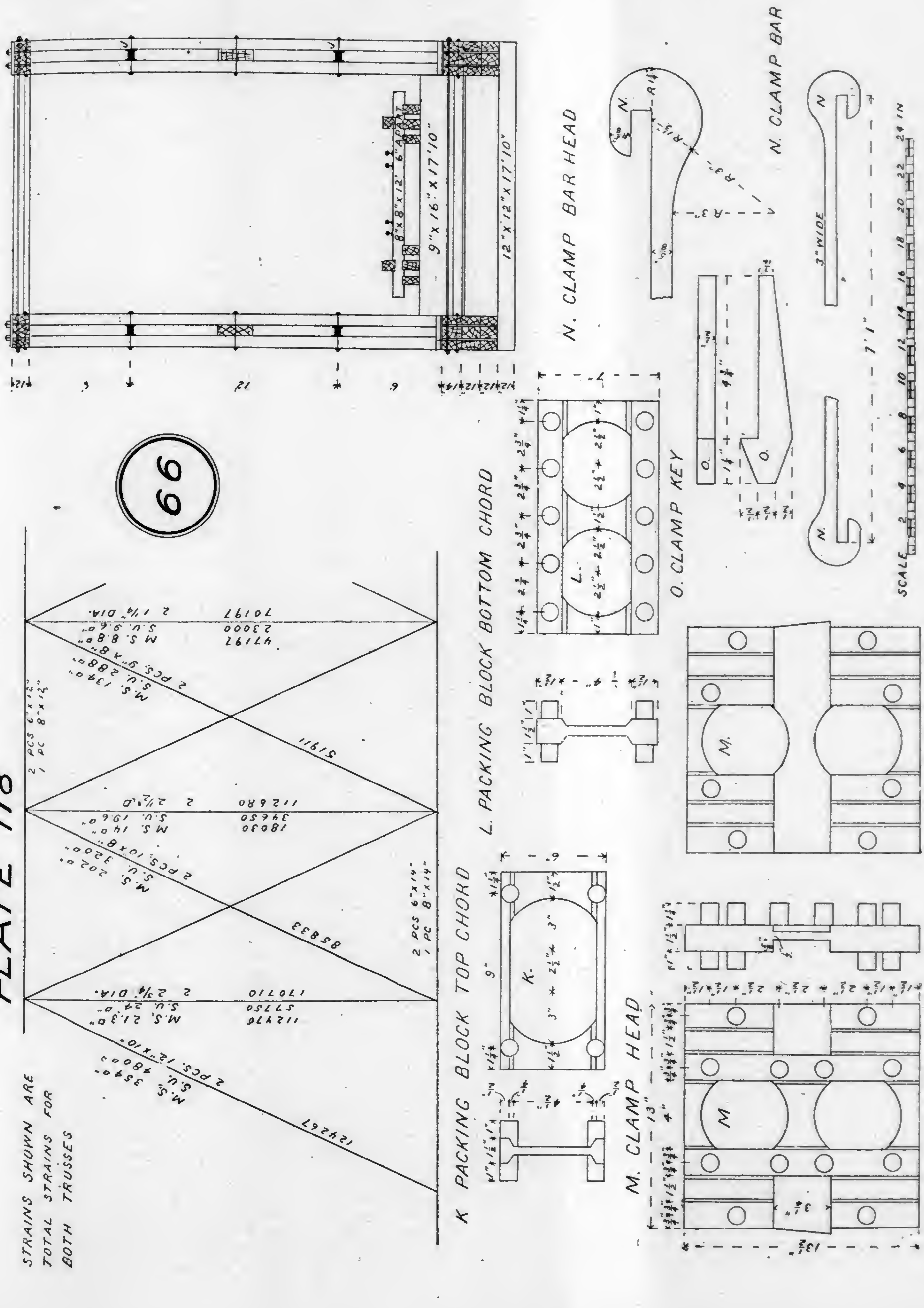
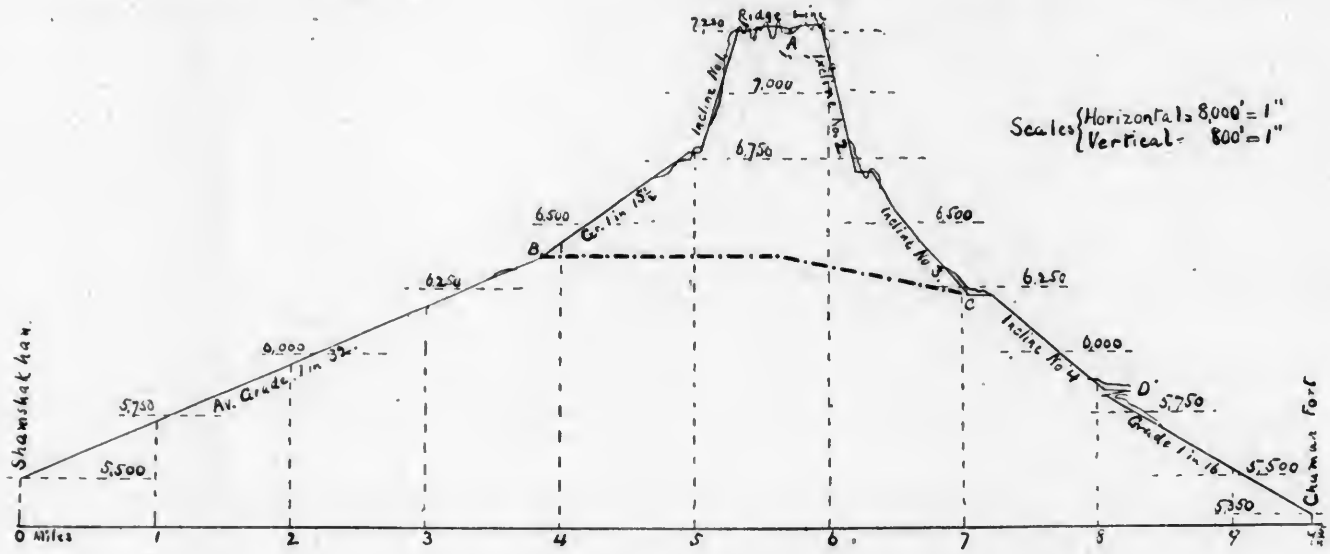


PLATE 118
STRAINS SHOWN ARE TOTAL STRAINS FOR BOTH TRUSSES
66
2 PCS 6"x12" 1 PC 8"x12"
2 PCS 6"x14" 1 PC 8"x14"
2 PCS. 12"x10"
M.S. 354□"
S.U. 480□"
124267
112476
57750
170710
M.S. 21.3□"
S.U. 24.□"
2 2 3/4 DIA.
85833
2 PCS. 10x8"
M.S. 202□"
S.U. 320□"
18030
34650
112680
M.S. 14□"
S.U. 19.6□"
2 2 1/2 D
51911
2 PCS. 9"x8"
M.S. 134□"
S.U. 288□"
47197
23000
70197
M.S. 8.8□"
S.U. 9.6□"
2 1 1/4 DIA.
8"x8"x12' 6" APART
9"x16"x17'10"
12"x12"x17'10"
K PACKING BLOCK TOP CHORD
L. PACKING BLOCK BOTTOM CHORD
M. CLAMP HEAD
N. CLAMP BAR HEAD
N. CLAMP BAR
O. CLAMP KEY
3" WIDE
7'1"
SCALE
24 IN.

Accordingly a careful survey was made with the object of ascertaining the feasibility of making a temporary railroad to be rapidly and cheaply constructed, pending the completion of the tunnel, and the line shown in the plate was the one finally decided on. The points which had to be borne in mind were:

1. As the lines would be in use for two or three years only, it was imperative that they should be constructed as cheaply and as quickly as possible.



PROFILE OF TEMPORARY LINE OVER THE KHOJAK PASS.

2. The lines should be of the standard gauge—5 ft. 6 in.—throughout.

3. The inclines should be able to take over ordinary locomotives and rolling stock; also wagons loaded with stores, etc., without breaking bulk.

4. The plant and appliances should be such as could be made in India, so as to avoid the delays inevitable in getting them out from England.

5. The carrying capacity should be not less than 400 tons per day, net.

The particulars of the four cable worked inclines are shown below:

DETAILS OF INCLINES.

INCLINE.	GRADE.	LENGTH.	VERTICAL HEIGHT.	MAXIMUM TRAIN-LOAD.	WORKING STRAIN OF CABLE.
No. 1.	1 in 2¾	1,320 ft.	452 ft.	30 tons.	12 tons.
No. 2........	1 in 2½	1,420 "	568 "	30 "	13 "
No. 3........	1 in 7 1 in 8 1 in 9 1 in 10	3,950 "	484 "	40 "	2½ "
No. 4........	1 in 8 1 in 12 1 in 13	4,700 "	376 "	50 "	4 "

It will be seen from the drawing that the temporary line after leaving the permanent line at Shamshakhan rises at first with an average grade of 1 in 22; this section is worked by locomotives, of the class known on the Government railroads as "Class L, heavy." After passing the East Tunnel mouth the grade steepens to 1 in 15½; this portion is worked by specially built engines. These are tank engines, with eight wheels, all coupled; they have 18 in. × 26 in. cylinders, and are fitted with hand, steam and Chatelier brakes on all eight wheels; they take a load of 54 tons up a grade of 1 in 15 and round 500 ft. curves—a very creditable performance. In order to increase their flexibility on the curves, the outside coupling rods are joined together with ball and socket joints, and the leading and trailing axle boxes have ⅝ in. play in the pedestals in each direction, or 1¼ in. altogether.

The ridge line on the summit has a ruling grade of 1 in 40, and is worked by two small locomotives, converted from meter to broad gauge; and the last section of 1 in 16 down to Chaman Fort is worked by tank engines similar to those in use on the East side.

On this ridge line one bridge was required, at the crossing of the military road, at the point marked *A* on the drawing.

The wire cables used on inclines Nos. 1 and 2 are 4½ in. in circumference, are composed of 114 wires each, and their breaking strain is 78 tons. The cables on inclines Nos. 3 and 4 are 2⅝ in. in circumference, of 72 wires, and have a breaking strain of 30 tons. The gauge of the track on all the inclines is 5 ft. 6 in., the standard gauge of the road. On Nos. 1 and 2 there is a single track; on Nos. 3 and 4 a double track.

In the drawing the figures on the dotted lines show height above mean sea level. The eastern junction with the permanent line is at Shamshakhan; the western at Chaman Fort. The heavy dotted line from *B* to *C* shows the level of the tunnel. A spiral or development is indicated at the foot of incline No. 4, at *D*.

Inclines Nos. 1 and 2 are worked by stationary engines fixed on the top, while Nos. 3 and 4 are self-acting.

In the case of Nos. 1 and 2, in consequence of the severe grade, it was necessary to run the ordinary vehicles on to specially designed inclined trucks, thus keeping the loaded wagon itself horizontal during its transit.

The temporary lines were completed and in working order in about a year, and cost in round numbers $178,500; they have carried up to date some 50,000 tons of stores for the Tunnel and Chaman Extension, the maximum day's work having been rather over 500 tons net.

COLLISIONS AT SEA.

BY LIEUTENANT H. H. BARROLL, U. S. N.

THE recent accident to the machinery of the *City of Paris* caused immediate and widespread anxiety. The fate of her hundreds of passengers was a matter of concern to thousands of homes on both sides of the Atlantic. Telegraph wires and ocean cables were busy transmitting the one question, "Where is the *City of Paris?*"

Such an occurrence emphasizes the importance of throwing all possible safeguards about transatlantic routes—especially along the great artery of commerce between Europe and American ports north of Cape Hatteras.

The world's ingenuity is constantly being exercised to

give to ocean travel the greatest security; and the modern large ocean steamer, as at present constructed, is as near perfection as the human mind can devise. From the original design, consisting of one or at most two compartments, generally with communicating passage-ways, the steamship of the present day is built with half a dozen separate transverse and longitudinal compartments, cellular bottoms, collision bulkheads, etc., while electric lights and steam steering gear greatly diminish the chances of collision.

Among the many dangers to which ocean travel is subject may be mentioned: collisions with ice, with other vessels, with sunken wrecks; grounding upon rocks or shoals; damage to the machinery or spars; dangers from fire or boiler explosions; mutinous crews; intemperate or incompetent officials. But of all dangers, *collision* is that which causes the greatest destruction of life and property.

Many ways have been devised, many laws enacted, and yet not a day passes but brings the news that, despite the precautions taken, accidents have occurred. Admiral Colomb, of the British Navy, in a speech recently delivered before the British Institute of Naval Architects, gave statistics showing that from three to five vessels are sunk each week by collision; while the number sometimes rises to seven.

The intemperance or incompetence of officials is no doubt responsible for many collisions; but this can in a great measure be guarded against by rigid examinations, and allowing promotion to follow only after a thorough exhibition of those qualities which go to make the capable seaman. There always remains the doubt, even after the most searching examination, as to whether the official has the habit of conducting himself properly when not under examination; and therefore a system which puts him under a certain amount of surveillance at all times will be found to be beneficial. The perfectly correct officer will not object to this surveillance, while the incorrect or incompetent one should be forced to stand it.

This system of careful examination is followed to the utmost extent in the promotion of officers serving aboard transatlantic steamers. They are required to serve a thorough apprenticeship in the lower grades, and in no other calling or service can nepotism or favoritism be said to have so little influence in determining promotion.

But there are dangers which still exist, despite the most careful system of inspection, and notwithstanding the most rigid examinations for competence. Shearing rivets, flaws in castings, cyclonic storms and dense fog banks will still cause trouble to the most experienced commanders, and endanger the most thoroughly constructed vessels. There is always a certain amount of danger to be encountered in threading one's way among thousands of other vessels, whose condition may not be so satisfactorily determined. It becomes as dangerous to meet a vessel in the hands of an ignorant officer as to sail under an incompetent commander.

To other trouble is added, so far as steamers are concerned, the necessity of avoiding the thousands of sailing vessels which throng the track between Europe and America, secure in the hard-and-fast rule which requires all steamers to keep out of the way of all sailing vessels, no matter what the circumstances of the case.

This pernicious "Rule Twenty" is responsible for many of the collsions which occur. The regulation was enacted at a time when the commerce of the world was carried in sailing vessels, and steamers were the exception and not the rule, as at present. It was evidently not the design of the framers of that regulation that small and handy cat-boats were to have the right to require a large 500-ft. vessel to change her course in a narrow channel, when by a touch of the helm the sailing vessel could steer clear and avoid all danger; yet such is the effect of this regulation, as at present interpreted.

On one occasion the great steamer *Oregon*, when entering the harbor of New York, was compelled to change her course, and almost run ashore upon the Jersey Flats, owing to the persistence of three young "toughs," who, in a Whitehall boat, defied the pilot to collide with them, they being "under sail."

There should be some modification of this rule, which requires steamships at all times to keep clear of sailing vessels. It may be argued that the commanders of steamers would themselves prefer that sailing vessels should "keep their course," and allow the steamship to do all of the manœuvering necessary to avoid a collision. If so, well and good; but let it be understood then that the sailing vessel *shall keep her course*, or else be considered in fault.

Numerous collisions are the direct result of change of course by sailing vessels at a critical moment, rendering it impossible for steamers to keep out of their way. In illustration of this, I quote from the New York *Herald* of May 6, in regard to the collision between the National Line steamer *Helvetia* and the American schooner *Bramhall*.

> Captain Cochrane, of the *Helvetia*, said that the schooner was on the port tack, and on the steamer's starboard bow. He at once stopped the steamer's engines, thinking the schooner would keep her course, and cross the *Helvetia's* bows. To Captain Cochrane's astonishment, the *Bramhall* was put in stays, and a moment later she drifted directly across the *Helvetia's* bows. The *Helvetia* had almost entirely lost steerage-way, and this made it impossible for her to get out of the schooner's way. It was the shock of the collision which knocked out the schooner's masts.

There is no occasion for the captain of the schooner to explain why he found it imperative to go into stays at this particular time—Rule Twenty renders it unnecessary for him to do this.

The grotesque feature of the occurrence appears when we realize that this collision takes place between a heavily laden steamer of about 4,500 tons and a small 135-ton schooner of some 5 or 6 ft. draft. The collision occurred off Tompkinsville, where the channel available for the steamer is at most 2,000 yards, and that for the schooner is more than 5,000 yards in width. The length of the steamer is 420 ft. and that of the schooner is 95 ft., and yet the captain of the *Helvetia* finds it necessary to attempt to excuse himself for "not getting out of the way of the schooner," which tacked under his bows.

The law with regard to the carrying of running lights requires that all sea-going vessels, when under way, shall carry, between sunset and sunrise, a red light on the port and a green light on the starboard side, these to be of such intensity as to admit of their being seen on a clear dark night to a distance of two nautical miles; and they are to be so placed as to show an unbroken arc of light from right ahead around to two points abaft the beam of that side upon which the light is placed.

The regulations also require that the boxes intended to contain the lights shall be so placed as to preclude the chance of the starboard light showing upon the port bow, and vice versa; and to that end, ordain that the light-boxes shall be fitted with an inner screening board, which shall extend at least three feet in front of the light, so as to prohibit its rays from showing across the bows.

The law supposes that the boxes shall be placed in a line parallel with the keel as regards the longitudinal plane, and in a line parallel with the water-line as regards the horizontal plane.

If at night an observer from right ahead sights a vessel with her lights properly placed, he will then see two colored lights, which will indicate to him that the vessel is directly approaching him. But in event of the observer being situated in any other than the infinitesimally small angle of "right ahead," he sees only one colored speck from which to judge the line upon which the vessel is steering.

In the case of a steamer, the law requires that she shall not only keep out of the way of a sailing vessel under all circumstances, but in order that she may publish the fact of her nature, the steamer is required to carry, in addition to the colored side-lights, a white mast-head light which shall show to a distance of at least five miles, and which indicates to the sailing ship that she is authorized to crowd, to the utmost, the unfortunate steamer. Therefore, the white mast-head light, while enabling the sailing vessel to determine with more exactness the steamer's course, becomes, so far as sailing vessels are concerned, an additional element of danger to the steamer's commander.

Notwithstanding the simplicity of the lights required by law, and the meagerness of the information which these guides furnish, there are hundreds of vessels now sailing the seas which disregard the law, or barely keep within the letter of the law, and thus save a few gallons of oil or the few moments of time it would require each day to put the lights in their boxes. Vessels are often only provided with the cheapest and least efficient means of complying with the law. They apparently only seek to be supplied with the material for evading the penalties of collision, rather than the means of avoiding collisions. Vessel owners, from a mistaken idea of economy, furnish their vessels with inferior lights, while the commanders will take advantage of all excuses to save the trouble and expense of keeping even these poor lights in proper position. Moderately light nights, long twilights and moonlight nights serve as excuses to delay, or even to omit placing these simple aids where they may be seen.

Simple deck lanterns, covered with green or red bunting, are made to do duty as red and green side-lights, and cases have been cited where plain white lanterns have been given a thin coating of green or red paint to cause them to emit the colored rays. All of this is manifestly illegal and also criminal, since it may lead to the loss of life or property. These attempts diminish the distance of visibility of the lights, and are in direct violation of the requirements of Rule 3 of Section 4,233 of the Revised Statutes, which provides that all colored running lights shall be of such intensity as to be visible at the distance of two nautical miles. No reduction in this distance should be allowed.

This is a very short time to allow the officer in charge of a swift steamer in which to decide how he is to clear the vessel, whose faint speck of a light he has just discerned. A steamer such as the *Etruria* or *City of Paris*, traveling at the rate of 20 knots an hour, will traverse a distance of 2,000 ft. in one minute, or a mile in three minutes. Two such steamers will approach each other, on opposite courses, at the rate of 46 miles an hour—the average rate of express trains. If it is considered necessary to carry the lights at all, it should be considered necessary to have them show to a distance of at least two nautical miles. Of course this is plenty of time in which to avoid a collision, provided that we know the exact course upon which the rival steamer is coming; but routes by sea are not as absolutely defined as are railroad tracks on shore, and it is therefore necessary to have some time in which to judge by change of bearing this line upon which she is steering.

Any person who has been to sea in an official capacity for any length of time will testify that he has, time and again, especially upon our own coasts, encountered vessels at night without the slightest sign of a light visible—also that not one-half of the side-lights carried by the ordinary small vessel are visible to the distance of two nautical miles. I am not far wrong in asserting that there are now hundreds of small vessels whose side-lights are not visible, under the most favorable circumstances, at a distance of one nautical mile.

At the recent Maritime Conference in Washington, it was announced by one of the Austrian delegates that 90 per cent. of the light was lost by its transmission through colored glass; and a Report recently made by a committee in Germany showed that red lenses absorbed 60 to 80 per cent. of the light's intensity, and green lenses absorbed 90 per cent.

When we take into consideration the effect of fogs and hazy weather in the reduction of this distance of visibility, and the manner in which vessels are crowded together, as their several courses converge at the entrances to such great ports as New York or Liverpool, it becomes a matter of surprise that collisions so seldom occur.

It is but justice to say that the great majority of the seagoing vessels which neglect to carry the required running lights are shown to be sailing vessels—principally the smaller craft. The very nature of the Rule which gives to these craft a practical monopoly of the ocean's surface, when contested by a steamer, causes them in many cases to disregard the proper precautions; and they are content to exhibit the running lights at the final moment, yet early enough under the law to clear themselves of the charge of not having had their lights burning. It is a common custom with some sailing vessels to put the running lights in the boxes only, when at night another vessel's lights have been sighted.

Not infrequently we will meet vessels carrying their side-lights simply lashed to the rigging, and therefore following the sheer of the vessel's bows. The screen extends in mockery three feet beyond the light, and the captain, in fancied security, is allowed to sail forth, causing more damage to maritime commerce than if he carried no lights at all.

Too much stress cannot be laid upon the importance of having the light-boxes properly placed. It will generally be found that the error in this position consists in thus permitting them to follow the sheer of the vessel's bow, thereby allowing their rays to intersect at some point ahead. Beyond this point both lights will improperly

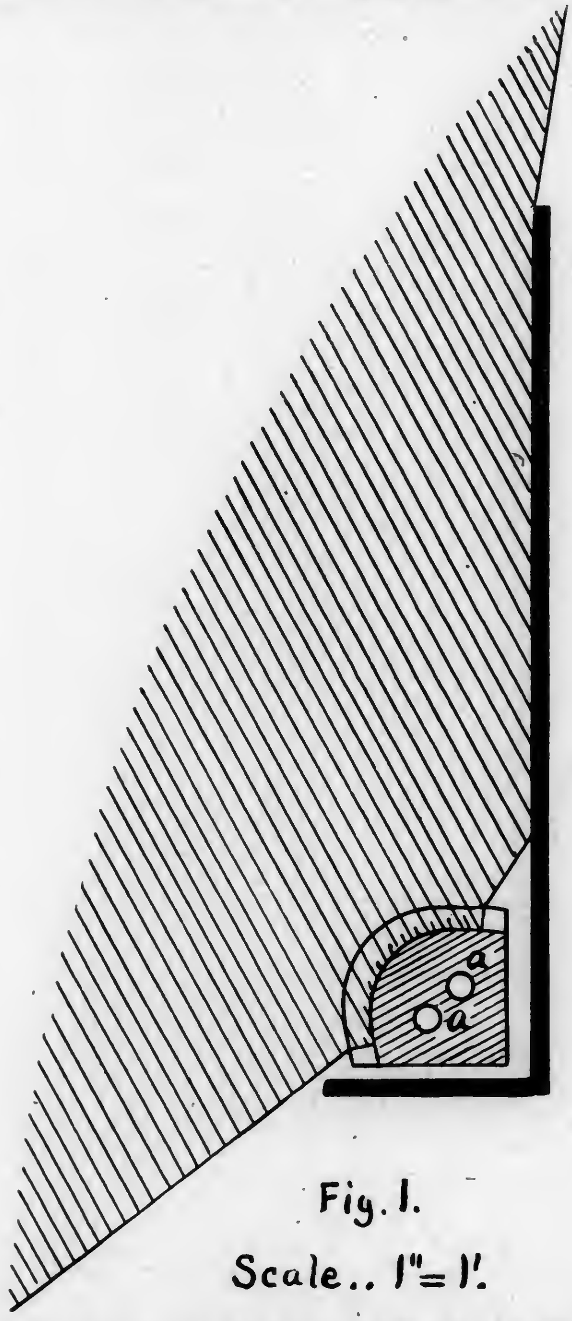


Fig. 1.

Scale.. 1" = 1'.

show across the bows. This point is the apex of an angle, which may be termed the "Angle of Error," since all observers situated within this angle are liable to be in error as to the course upon which an approaching vessel is steering.

The distance of this point of intersection from the vessel's lights will of course depend directly upon the amount of error in the position of her lights, as well as upon the breadth of beam of the vessel carrying the lights.

If the light-boxes were placed so as to allow the colored lights to show only directly ahead, as the law requires, then theoretically there would be a belt extending ahead, and equal in width to the beam of the vessel, inside of which space neither the red nor the green light would be seen. The only point where the two lights could possibly be seen at the same instant would be at the vanishing point of these two parallels, drawn along the starboard and port sides of the vessel.

But in practice we know that this is not the case, and that at a comparatively short distance ahead of the vessel her two colored lights can be seen simultaneously. This is due to the fact that the lanterns themselves are not in line with the fore-and-aft screens. Although the light-screens may be placed in the exact fore-and-aft line, the rays proceeding from the outer parts of the lenses will still cause the light to be seen across the bow.

Commander F. E. Chadwick, U. S. N., commanding the U. S. Steamer *Yorktown*, in a report concerning the recent trial of range-light systems, calls attention to this fact in the following words :

> It will be observed that there are large discrepancies between the estimates of observers and the actual bearings in some of the double-light observations. This arose largely from the fact that the lights show over greater angles than intended. I have had a trial made of the arc of illumination of the side-lights of this ship, and find that the light itself will show, actually, as far aft as three points on the quarter (the reflection of the light on the sides of the light-box—the lights are electric, and very brilliant—showing considerably further aft), and across the bow one and three-quarter points.
>
> I think very few if any of the lights used are accurate in regard to the illuminated arc. Every portion of the flame throws a ray, and tangents drawn from its circumference to the edges of the light-box mark properly the limits of illumination.

Fig. 1 represents the light and light-box of this vessel on a scale of 1 in. to the foot. This shows the angle over which the *Yorktown's* lights must necessarily show, although they actually show much further—both across the bows and abaft the beam.

In the other diagrams the lines have been drawn at arbitrary angles, but will suffice to illustrate the effect of additional error in the placing of the side-lights. It is evident that, from the causes mentioned by Commander Chadwick, there will be a constant error, even when the light-screens are placed in an exact fore-and-aft line. This, for the ordinary lantern, will be an error of about 8°.

In fig. 2, in the small triangle $X\ Y Z$, representing the light and the light-box of a vessel, suppose $X\ Y$ to represent 6 in. (which would probably be the width of the smallest lantern carried) and $Y Z$ to represent the screening board, which is to extend 3 ft. beyond the light ; the tangent of the angle at Z would be 6 in. divided by (36 + 6) 42 in., or,

$$Z = 8° 8'.$$

This, then, will necessarily cause lights to show across the bows of a vessel of 15 ft. beam, at a distance of about 50 feet, and a vessel of 30 ft. beam, at a distance of about 100 ft. in front of the vessel's lights.

To demonstrate the effect of additional error in the placing of the light-boxes, let $A\ B$ (fig. 3) represent the half-beam of a vessel, C the point of intersection of the rays with the midship line, after leaving the properly placed screening-board, and C the point of intersection due to additional error. The secant $B C'$ cutting the two parallels, $B\ O$ and $A\ C'$, the angle at C' represents the total deviation from a direct line ahead ; or the constant angle (8°) at C, plus the additional angular error of the light screens from a fore-and-aft line.

In the triangle $A\ B\ C'$,

$$\text{tangent } C' = A\ B \div A\ C'$$
$$A\ C' = A\ B \times \text{cotangent } C'.$$

By this it will be seen that an additional error of one point ($11\frac{1}{4}°$) will cause the rays from the outer part of the lens to intersect the midship line of a vessel of 15 ft. beam, at a distance of only 21.3 ft., and with a vessel of 30 ft. beam, at a distance of only 42.6 ft., ahead of the the screening boards.

There is, then, beyond this point, a constantly widening angle, in which an observer is liable to be deceived, supposing that by seeing two lights at once he can estimate within the customary $\frac{3}{4}$ of a point the course upon which the vessel is approaching.

The foregoing are the principal sources from which collisions arise ; and the only way to prevent their occurrence is to endeavor, by close inspections and heavy penalties, to obtain strict observance of the existing laws. The Washington Maritime Conference has made a step in the right direction in discussing the several excellent systems of range-lights, and in calling attention to the loss of light by transmission through colored lenses ; but the greatest improvement that could be made would be in the strict enforcement of the present rules regarding the placing and

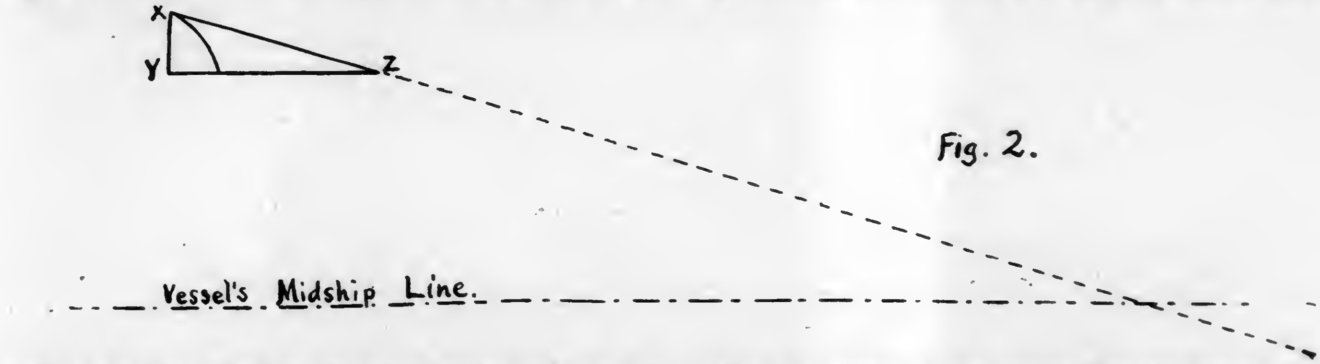


Fig. 2.

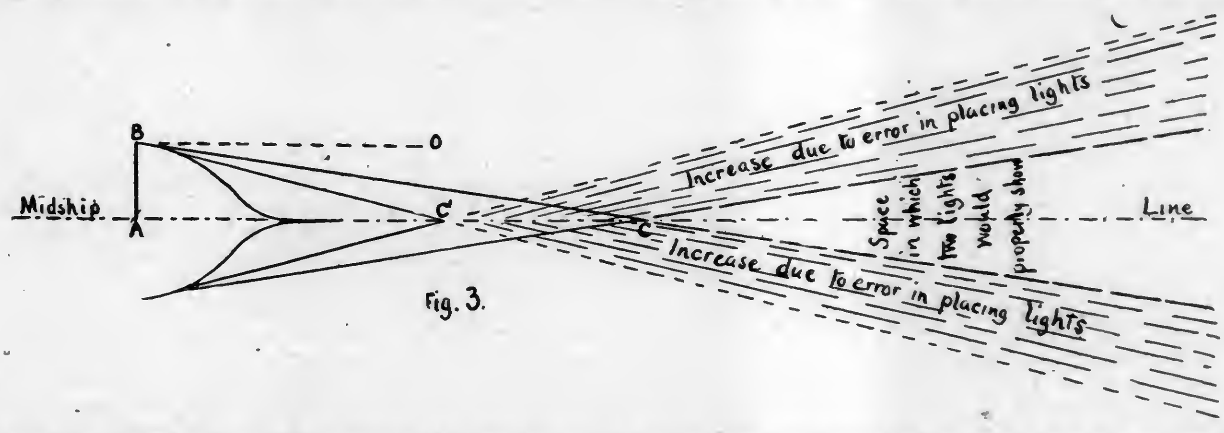


Fig. 3.

carrying of the lights now demanded by the law. Until we can be sure that the present simple and cheap requirements are provided according to existing law, it is sheer waste of time to formulate new regulations or prescribe additional lights, fog-whistles, etc.

Lights should show to some definite distance, and to insure this there should be some official inspection of the lights themselves, some testing examination of the running lights, before they are allowed to be sold. Such examinations are made by Government officials for steam-boilers, steam gauges, etc., and why should not the same care be taken with the means for avoiding collisions ?

All lights should be clearly stamped with the name or the initials of this inspecting officer, and no lights should be allowed to be carried on board of any civilized country's vessels unless they had the inspector's mark.

This inspection should also include, in addition to the test for distance of visibility, an examination to show that the lens emitted the required colored rays. Side-lights are often seen doing service as green lights, and the color of the rays will be almost white—or used as red lights, with almost yellowish rays.

There seems to be in the United States no regular inspection of the light-boxes of vessels to determine if these are properly placed. In conversation with a captain of a sailing vessel, I was told the other day that, in an experience of over 35 years as commanding officer, he had never been called upon to show either that the lights which his vessel carried were of the proper quality, or that they were properly placed.

Many commanders of vessels have assured me that they would be glad to submit to any such inspection in order to have other vessels come under the same examination. It would lead to good results to institute such an inspection, with the proviso that thereafter any vessel found carrying inefficient lights, or these improperly placed, should forfeit her register.

It will be argued that this is impracticable--that it imposes additional expenses upon small vessels, which already have to pay heavy running expenses. The only answer to this is, that any vessel that is too small to warrant her carrying the necessary and reasonable means required by law for her safety and that of other vessels at night, should not be allowed to be abroad during that time.

Even supposing that she is the only sufferer by the collision, the fact yet remains that in most cases any officer will endanger his own vessel's safety, in hope of avoiding a collision, rather than deliberately run down another vessel, although the latter may be clearly in the wrong.

A great element of safety could be introduced into transatlantic travel if the passengers could be made to clearly understand the great risks that they are required to undergo when the officials disregard the requirements of the law.

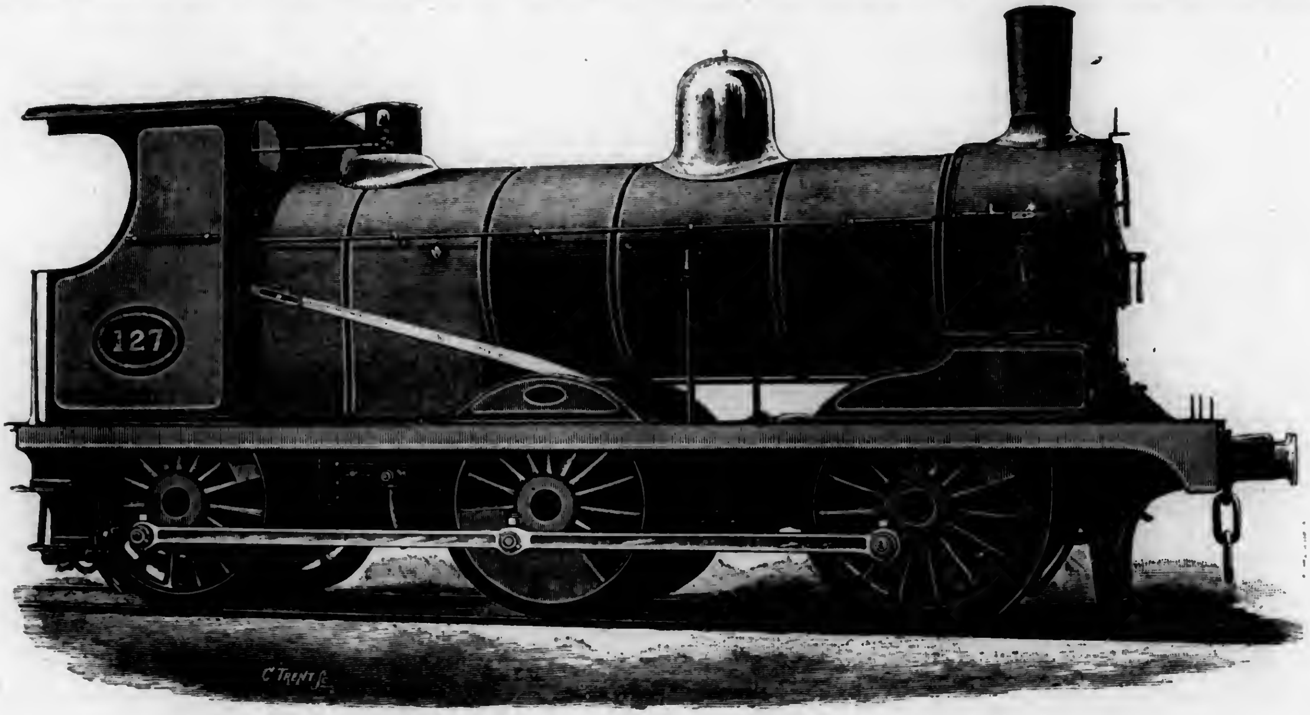
Transatlantic travel has now become so common that even the layman is to a certain extent aware of the principal dangers to be apprehended ; and although the captain, from his citadel of reserve, may parry the questions of the anxious passenger, yet there are times when such danger makes itself too painfully apparent.

When, some years ago, a large steamship ran at the rate of 10 knots, full tilt, into an enormous iceberg—a solid island of ice—and tore off about 15 ft. of her bows, there was no need for the officers to announce to the passengers that the practice of running fast in a fog is a dangerous one.

The North Atlantic Pilot Chart, issued by the United States Hydrographic Office for each month, shows carefully defined lines at which ice or fogs may be expected. These predictions are now based upon observations extending over nearly 50 years, and are the experience of hundreds of thousands of voyages. It is a part of the great meteorological system inaugurated by Maury ; and the determining of the approximate limits of fog and ice is of as much importance to navigators as is the locating of the current of the Gulf Stream, a fact of which so much use has been made.

Collisions with ice, wrecks, and with other steamers are mainly due to the obscurity caused by the fog banks, and in many cases are the direct results of proceeding at an imprudent rate of speed, and could be sensibly diminished by strict adherence to the routes which have been shown to lie comparatively clear of these dangers.

It is possible that upon the safe arrival of the above-mentioned vessel in harbor, the usual letter, commendatory of the skill and coolness of captain and officers, was circulated, and signed by the passengers in gratitude for their escape. If so, this was a mistake, and the paper should have been sent instead to the careful ship-builders on the Clyde, whose honest riveting, close inspection, and attention to detail rendered the tight-fitting bulkheads capable of counteracting the consequences of the captain's mistake.



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THE accompanying illustration, from the *Railway Engineer*, shows a six-wheel connected compound locomotive, of the Worsdell-Von Borries type, built for freight service

on the Great Eastern Railway, at the shops of that company in Stratford, England, and from the plans of Mr. James Holden, Locomotive Superintendent of the road.

The boiler is 52 in. diameter of barrel; the fire-box is $63\frac{3}{4}$ in. long by $40\frac{1}{4}$ in. wide inside, the depth being $67\frac{1}{2}$ in. in front and $61\frac{1}{2}$ in. at the back. There are 252 tubes, $1\frac{5}{8}$ in. outside diameter and 10 ft. 4 in. long. The area of the grate is 17.9 sq. ft.; the heating surface is: Fire-box, 105 sq. ft.; tubes, 1,109 sq. ft.; total, 1,214 sq. ft. The usual working pressure is 175 lbs. The boiler shell is of steel; the tubes are of steel, and the fire-box of copper.

The wheels are 58 in. in diameter; the bearings are $7\frac{1}{2}$ in. in diameter and 9 in. long. The crank-axle has the journals for the connecting rod 8 in. in diameter and $4\frac{1}{2}$ in. long. The frames are of the plate type, and are of steel, $1\frac{1}{8}$ in. thick. The distances between centers of axles are 7 ft. 7 in. and 8 ft. 6 in. respectively.

The high-pressure cylinder is 18 in. in diameter and the low pressure 26 in., both being 24 in. stroke. The cylinders are inside, with the steam-chests on top. The valve motion is of the shifting link type. The high-pressure cylinder has steam ports $1\frac{3}{4} \times 12\frac{3}{4}$ in., exhaust ports $3\frac{1}{2} \times 12\frac{3}{4}$ in.; the valve has $\frac{7}{8}$ in. lap and $\frac{1}{4}$ in. inside clearance, the maximum travel being $3\frac{7}{8}$ in. The low-pressure cylinder has steam ports $2 \times 16\frac{1}{2}$ in., exhaust ports $3\frac{1}{2} \times 16\frac{1}{2}$ in.; the valve has $\frac{7}{8}$ in. lap, $\frac{3}{16}$ in. inside clearance, and a maximum travel of $3\frac{7}{8}$ in. The valves are of bronze and the pistons of wrought iron. The engine has a variable exhaust, controlled from the foot-board.

The boiler, it will be seen, is of the straight-top pattern. The center of the boiler is 7 ft. 6 in. above the rails. The total height from rail to top of smoke-stack is 12 ft. 11 in. The total length of the engine is 24 ft. 10 in.

The total weight of this locomotive in working order is 88,300 lbs., of which 33,300 lbs. are carried on the forward pair of wheels, 30 600 lbs. on the main driving wheels, and 24,400 lbs. on the rear or trailing wheels.

THE RAILROADS OF THE UNITED STATES.

THE publishers of *Poor's Manual of the Railroads of the United States* have for some years past issued a carefully prepared summary of the general railroad operations of the year, made up from the figures furnished for the *Manual*. This summary has the disadvantages that it is made up from statistics covering varying fiscal years and varying forms of report, and that the figures are not officially required, but furnished voluntarily by the companies. On the other hand, it is at present the only source attainable for a general review of the railroads; the figures are probably correct as furnished, and are carefully analyzed and compared, so that they give an approximately correct view of the condition and progress of the railroads of the United States which is both interesting and valuable.

In the accompanying table are given, for 1889, the main results as expressed in the Introduction to the *Manual*, with a few slight changes in form only. The comparisons made are with the figures obtained from the same source for the year 1888.

RAILROADS OF THE UNITED STATES IN 1889.

	1889.	Increase or Decrease.		Per cent. of Change.
1. Property:				
Total mileage of roads	160,544	I.	6,268	4.1
Additional tracks and sidings	42,242	I.	5,021	13.3
Total miles track.	202,786	I.	11,289	5.9
Miles laid with steel rails	151,723	I.	13,207	9.6
" " " iron "	51,063	D.	1,918	3.6
No. of locomotives	31,062	I.	1,664	5.7
" passenger cars	23,465	I.	2,040	9 5
" baggage, mail, etc	7,184	I.	357	5.3
" freight cars	1,060 164	I.	55,048	5.5
Total amount of stock	$4,495,099,318	I.	$92,687,976	2.1
" " " bonds	4,828,365,771	I.	204,330,748	4.4
" " " other debts	607,988,057	I.	62 947,113	11.5
Total liabilities	$9 931,453,146	I.	$359 965,837	3 8
Operations:				
Miles of road operated	152,689	I.	7,348	5.1
Total earnings	$1,081,661,004	I.	$46,141,116	4.4
Working expenses	674,731,517	I.	21,473,186	3.3
Net earnings	$406 929,487	I.	$24,667,930	6.5
Charges—interest etc	296,870,104	I.	10,259 598	3 6
Profit	$110,059,383	I.	$ 4,408,332	15.1
Total amount of dividends	79,532,863	I.	589,822	0.7
Miles run by revenue trains	723,772,142	I.	35,020,771	5.1
Passengers carried, number	495,124,769	I.	43,771,112	9.7
Passenger-miles	11,965,726,015	I.	775,112 336	6.9
Tons freight carried	619,137,237	I.	28,279,884	4.8
Ton-miles	68,604,012,396	I.	3,181,006,408	4.9
Averages:				
Earnings per mile of road	$7,084	D.	$41	0.6
Net earnings per mile of road	2,665	I.	35	1.3
Per cent of expenses	62.38	D.	0.71	......
Earnings per train mile	137.200 cts.	D.	0.800 ct	0.6
Expenses " " "	93.300 "	D.	1.500 "	1.6
Earnings per passenger-mile	2.170 "	D.	0.076 "	3.4
" " ton-mile	0.976 "	D.	0.001 "	0.1
Average passenger journey	24.17 miles.	D.	0.61 mile.	2.5
" freight haul	110.80 "	I.	0.08 "	0.1
" passenger-train load	42.12 pass.	I.	0 90 pass.	2.2
" freight-train load	156.05 tons.	D.	0.67 ton.	0.4

Passenger business furnished about 27 per cent. of the gross earnings, freight 66.4 per cent., miscellaneous earnings—mail, express, etc.—making up the remaining 6.6 per cent. The proportion of passenger business to the total shows a slight increase over 1888.

The interest and dividends paid amounted to about 3 per cent. on the total stock and debt; but the dividends alone were only 1.77 per cent. on the total amount of stock. Of course a large part of the stock received no dividend whatever.

Taking the population on the basis of the Census of 1880, the United States has now one mile of railroad to 18.75 square miles of territory, or to 404 inhabitants; the last figure is probably too small, as the increase in population since 1880 has been considerable.

The *Manual* calls attention again to the steady decrease in rates. In eight years the passenger mileage of the railroads has increased 71 per cent., but the average rate per passenger-mile has fallen from 2.514 to 2.170 cents, a decrease of $13\frac{3}{4}$ per cent. With freight rates this has been still more marked; the increase in ton-miles in eight years has been almost the same as in passenger traffic, 72 per cent., but the average rate per ton-mile has fallen from 1.236 cents to 0.976 cent, a loss of 21 per cent. The reduction in expenses has, however, about kept pace with that in rates.

It is to be noted that while the increase in freight-train mileage has been less than that in freight traffic, that in passenger-train mileage has been greater; so that, while the average freight-train load increases every year, the average passenger-train load is actually less than it was eight years ago.

The results of the year in a general way were good, the figures showing a heathy gain in traffic, with a reduction in working expenses and a consequent increase in traffic. One result of this has been the expenditure of large sums in improvements, as shown in the increases in the number of locomotives and cars and in the increase in mileage of track laid with steel, replacing the old iron rails, which are now gradually but steadily disappearing from the tracks, and in a few years will be entirely gone.

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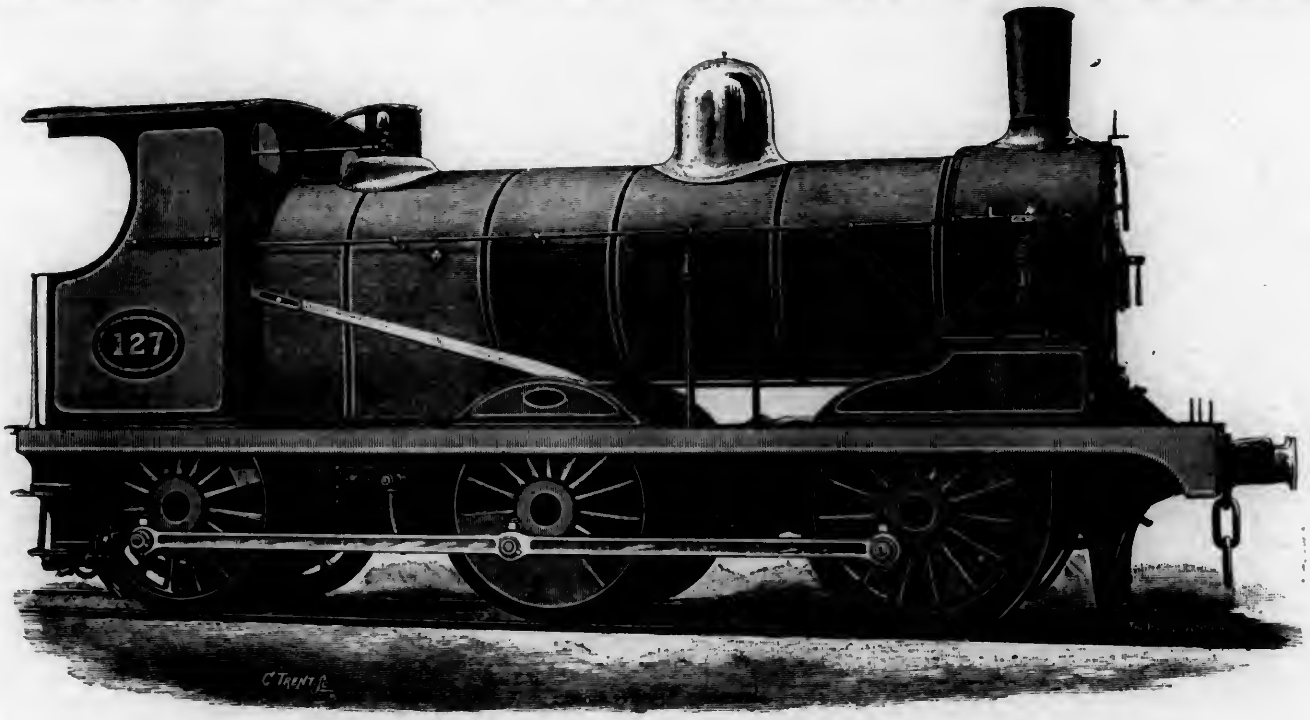

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The high-pressure cylinder is 18 in. in diameter and the low pressure 26 in., both being 24 in. stroke. The cylinders are inside, with the steam-chests on top. The valve motion is of the shifting link type. The high-pressure cylinder has steam ports $1\frac{3}{4} \times 12\frac{3}{4}$ in., exhaust ports $3\frac{1}{2} \times 12\frac{3}{4}$ in.; the valve has $\frac{7}{8}$ in. lap and $\frac{1}{4}$ in. inside clearance, the maximum travel being $3\frac{7}{8}$ in. The low-pressure cylinder has steam ports $2 \times 16\frac{1}{2}$ in., exhaust ports $3\frac{1}{2} \times 16\frac{1}{2}$ in.; the valve has $\frac{7}{8}$ in. lap, $\frac{8}{16}$ in. inside clearance, and a maximum travel of $3\frac{7}{8}$ in. The valves are of bronze and the pistons of wrought iron. The engine has a variable exhaust, controlled from the foot-board.

The boiler, it will be seen, is of the straight-top pattern. The center of the boiler is 7 ft. 6 in. above the rails. The total height from rail to top of smoke-stack is 12 ft. 11 in. The total length of the engine is 24 ft. 10 in.

The total weight of this locomotive in working order is 88,300 lbs., of which 33,300 lbs. are carried on the forward pair of wheels, 30 600 lbs. on the main driving wheels, and 24,400 lbs. on the rear or trailing wheels.

THE RAILROADS OF THE UNITED STATES.

THE publishers of *Poor's Manual of the Railroads of the United States* have for some years past issued a carefully prepared summary of the general railroad operations of the year, made up from the figures furnished for the *Manual*. This summary has the disadvantages that it is made up from statistics covering varying fiscal years and varying forms of report, and that the figures are not officially required, but furnished voluntarily by the companies. On the other hand, it is at present the only source attainable for a general review of the railroads; the figures are probably correct as furnished, and are carefully analyzed and compared, so that they give an approximately correct view of the condition and progress of the railroads of the United States which is both interesting and valuable.

In the accompanying table are given, for 1889, the main results as expressed in the Introduction to the *Manual*, with a few slight changes in form only. The comparisons made are with the figures obtained from the same source for the year 1888.

Passenger business furnished about 27 per cent. of the gross earnings, freight 66.4 per cent., miscellaneous earnings—mail, express, etc.—making up the remaining 6.6 per cent. The proportion of passenger business to the total shows a slight increase over 1888.

The interest and dividends paid amounted to about 3 per cent. on the total stock and debt; but the dividends alone were only 1.77 per cent. on the total amount of stock. Of course a large part of the stock received no dividend whatever.

Taking the population on the basis of the Census of 1880, the United States has now one mile of railroad to 18.75 square miles of territory, or to 404 inhabitants; the last figure is probably too small, as the increase in population since 1880 has been considerable.

The *Manual* calls attention again to the steady decrease in rates. In eight years the passenger mileage of the railroads has increased 71 per cent., but the average rate per passenger-mile has fallen from 2.514 to 2.170 cents, a decrease of $13\frac{3}{4}$ per cent. With freight rates this has been still more marked; the increase in ton-miles in eight years has been almost the same as in passenger traffic, 72 per cent., but the average rate per ton-mile has fallen from 1.236 cents to 0.976 cent, a loss of 21 per cent. The reduction in expenses has, however, about kept pace with that in rates.

It is to be noted that while the increase in freight-train mileage has been less than that in freight traffic, that in passenger-train mileage has been greater; so that, while the average freight-train load increases every year, the average passenger-train load is actually less than it was eight years ago.

The results of the year in a general way were good, the figures showing a heathy gain in traffic, with a reduction in working expenses and a consequent increase in traffic. One result of this has been the expenditure of large sums in improvements, as shown in the increases in the number of locomotives and cars and in the increase in mileage of track laid with steel, replacing the old iron rails, which are now gradually but steadily disappearing from the tracks, and in a few years will be entirely gone.

RAILROADS OF THE UNITED STATES IN 1889.

	1889.	Increase or Decrease.		Per cent. of Change.
1. *Property:*				
Total mileage of roads	160,544	I.	6,268	4.1
Additional tracks and sidings	42,242	I.	5,021	13.3
Total miles track	202,786	I.	11,289	5.9
Miles laid with steel rails	151,723	I.	13,207	9.6
" " " iron "	51,063	D.	1,918	3.6
No. of locomotives	31,062	I.	1,664	5.7
" passenger cars	23,465	I.	2,040	9 5
" baggage, mail, etc	7,184	I.	357	5.3
" freight cars	1,060 164	I.	55,048	5.5
Total amount of stock	$4,495.099,318	I.	$92,687,976	2.1
" " " bonds	4,828,365,771	I.	204,330,748	4.4
" " " other debts	607,988,057	I.	62 947,113	11.5
Total liabilities	$9 931,453,146	I.	$359 965,837	3 8
Operations:				
Miles of road operated	152,689	I.	7,348	5.1
Total earnings	$1,081,661,004	I.	$46,141,116	4.4
Working expenses	674,731,517	I.	21,473,186	3.3
Net earnings	$406 929,487	I.	$24,667,930	6.5
Charges—interest etc	296,870,104	I.	10,259 598	3 6
Profit	$110,059,383	I.	$ 4,408,332	15.1
Total amount of dividends	79,532,863	I.	589,822	0.7
Miles run by revenue trains	723,772,142	I.	35,020,771	5.1
Passengers carried, number	495,124,769	I.	43,771,112	9.7
Passenger-miles	11,965,726,015	I.	775,112 336	6.9
Tons freight carried	619,137,237	I.	28,279,884	4.8
Ton-miles	68,604,012,396	I.	3,181,006,408	4.9
Averages:				
Earnings per mile of road	$7,084	D.	$41	0.6
Net earnings per mile of road	2,665	I.	35	1.3
Per cent of expenses	62.38	D.	0.71	......
Earnings per train mile	137.200 cts.	D.	0.800 ct	0.6
Expenses " " "	93.300 "	D.	1.500 "	1.6
Earnings per passenger-mile	2.170 "	D.	0.076 "	3.4
" " ton-mile	0.976 "	D.	0.001 "	0.1
Average passenger journey	24.17 miles.	D.	0.61 mile.	2.5
" freight haul	110.80 "	I.	0.08 "	0.1
" passenger-train load	42.12 pass.	I.	0 90 pass.	2.2
" freight-train load	156.05 tons.	D.	0.67 ton.	0.4

Fig. 1.

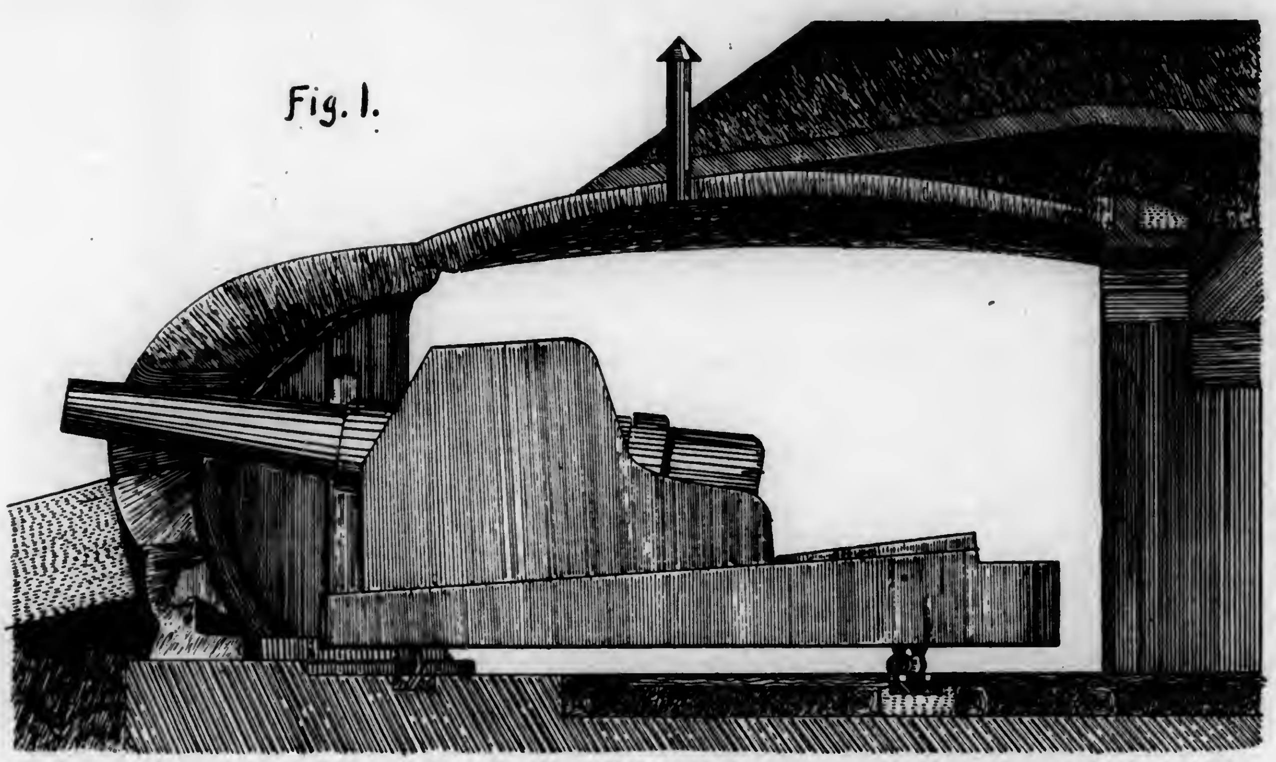


Fig. 2.

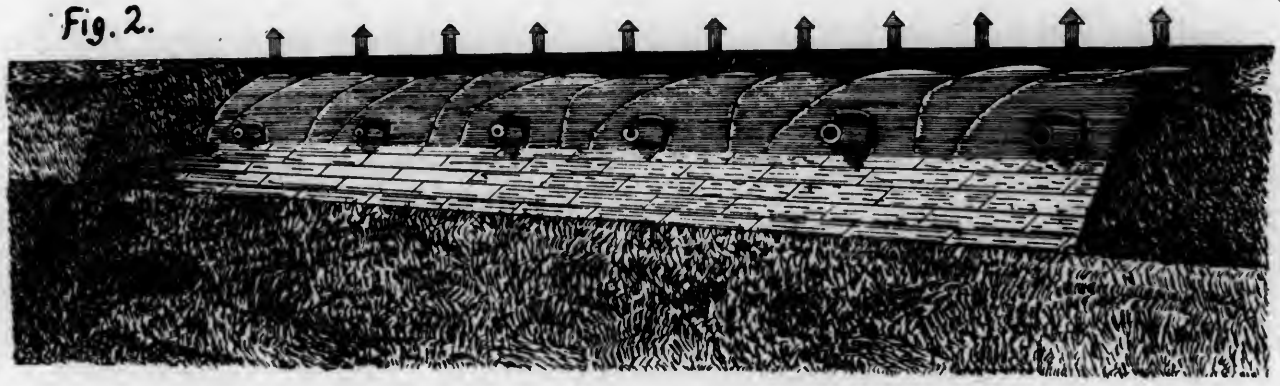


Fig. 3

THE DEVELOPMENT OF ARMOR.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

(*Continued from page* 371.)

XV.—ARMOR AS APPLIED TO LAND DEFENSES.

One of the many lessons taught by the War of the Rebellion was that brick and granite were no match for rifled cannon. The experience of Fort Pulaski, in 1862, of Fort Sumter in the following year, confirmed at Strasburg during the Franco-German War, demonstrated beyond a doubt the vulnerability of masonry before rifled guns of very moderate power, and that the elaborate piles of stone and mortar which so long had defied all attack except the slow approach by pick and shovel, had become death-traps under the new conditions of warfare. The military engineer was perforce compelled to seek some other material with which to construct sea-coast and inland fortifications. The advance already made in the application of metal to ships of war furnished a solution to the problem.

The development of armor-plate, as applied to ships, has already been sufficiently discussed. The experience there gained was of great value when its employment upon land defense became a necessity. The form in which metal should be used—whether as wrought-iron, cast-iron or as steel; the character of the structures to which it should be applied, with many other details, are questions about which there is wide difference of opinion; only upon the single point that metal in some shape, either alone or in combination with other materials, must be employed, has there been unanimity of view. It is proposed to notice briefly the systems that already have been put in actual practice, or that have received the sanction of practical military engineers.

The ideal armor-plate is, no doubt, one that combines the virtues of the two distinct varieties of armor—hard and soft—that is, one that, while presenting a hard, rigid, unyielding surface to the impact of a shot, has behind it an elastic, tenacious interior that will hold the hard outer layers up to their work, at the same time localizing the effect of a blow, and preventing cracks and fissures from spreading from front to rear, as is the case in homogeneous metal. The elasticity of the backing also tends to distribute the effects of the blow from the point of application over the whole mass. Compound armor is the practical outcome of efforts to secure this end, and to-day all varieties of armor-plate—the all steel and the Grüson cast-iron, of which we are about to speak—aim to combine a hard face with a relatively soft and elastic back.

XVI.—GRÜSON'S CHILLED IRON ARMOR.

As early as 1868 Herr Grüson brought forward his chilled cast-iron armor, and since that date it has gradually grown in favor, and now occupies a very important position in the matter of material for permanent forts and fortifications. As has been previously stated, Grüson's cast-iron owes its success to the superior grade of iron employed, and the peculiar method of casting. In selecting his materials two kinds of pig-iron are chosen, each possessing one of the desired qualities—one a highly carbonized, hard white iron, the other a soft gray iron. In the casting, the object to be attained is "to combine the different materials together with such gradual changes of their respective properties that no marked line of separation should occur." The result is obtained by the use of iron moulds, which prevent, by a rapid cooling of the surface, the tendency in a fluid casting of the carbon to separate off in the form of scales of graphite. In examining the fracture of a Grüson casting there is no noticeable line of demarcation between the hard outer surface and the soft gray iron of the interior.

The Grüson chilled iron-armor is employed in two general classes of works—protected fixed batteries and revolving turrets; the questions of volume of fire to be obtained, of site and of available space deciding in each instance the character of the work to be constructed. Aside from the quality of metal employed, it is claimed for the Grüson system that the curved surface given to the plates adds enormously to their resisting powers; that by their peculiar form the plates support each other, and that their great weight renders bolting together unnecessary. Further, that by pivoting the gun carriages within the port, this aperture is reduced to but slightly greater dimensions than the chase of the gun, thus rendering port-shutters or screens unnecessary.

Fig. 1 shows in section a Grüson armored battery. The port or embrasure plates form the chief part of the armor. These are supported on either side by pillar plates, and rest upon pivot plates. Protection against curved fire is obtained by roof-plates, which in front join the port and pillar plates, and in rear rest upon pillars of masonry forming part of the casemate. Stability is secured by planing to a flat surface the adjoining edges of the several plates, and providing each edge with a corresponding groove into which melted zinc can be run or iron plugs inserted when the battery plates are put in place. The whole rests upon a solid masonry foundation. The ends of the battery rest against masonry covered with a parapet of earth. Immediately in front of the guns is a mass of concrete covered with granite blocks. The magazines are placed in the basement of the casemates, with which they communicate by means of stairways and lifts. Fig. 2 gives an exterior view of such a battery.

Where only a limited area of site is obtainable, or a large arc of horizontal fire is desired, revolving turrets, whose fire can be delivered through the whole 360° of arc, are resorted to. Fig. 3 gives a sectional view of a Grüson chilled iron turret, from which the general details of construction can be easily understood. The sides of a turret, or cupola, are almost identical in shape with the port-plates of an armored battery previously explained. The dome-shaped cover, or roof, is made up of a number of separate plates, and so constructed that their center of gravity passes through the middle point of the structure. They are held in place by their own weight. The whole rests upon a wrought-iron substructure, which in turn rotates on a live roller ring running on a roller path fixed to the foundation. This live roller way is without a central pivot, which allows the whole interior space to be utilized, it being possible to mount the guns through the central space from below. Transverse girders, fixed to the lower part of the iron substructure, support the guns and carriages. As in the battery, the adjoining edges of the roof and side plates are provided with grooves, and are secured in the same manner when the turret is set up. The base of the turret is protected, either wholly or in part, as may be required, by a glacis armor or ring of cast-iron plates. This is further protected by a layer of concrete covered with granite blocks.

The turret is rotated by pinion gear working in a circular rack, fixed to the upper roller-path. The gear may be worked either by a capstan hand-gear or by power. Twelve men are required to work the 12 in. gun, and can revolve the turret through the quarter of a circle in 4 minutes.

In the top of the turret is a man-hole, and sighting holes are provided for sighting the guns—a speaking-tube communicating with the man in charge of the steering gear. The magazines are in the basement. The cartridges are hoisted through a tube to the middle platform. The shell magazine is in the center chamber below the guns. The projectiles are raised by a lift to the platform under the cupola, from which a crane takes them to the breech of the gun.

The Spezzia turrets, for the four 119-ton Krupp guns, are constructed upon much the same model as represented in fig. 3, and are made up of 15 side and an equal number of glacis cast-iron plates, and have an interior diameter of about 33 ft. The turret for the 12-in. has of side and glacis plate, 11 each.

XVII.—EXPERIMENTS WITH CAST-IRON ARMOR.

The first experimental tests of Grüson cast-iron armor began in 1869, and continued until 1874. During this time

eight series of tests were had, with guns varying in caliber from 5.9 to 11 in., firing chilled iron projectiles against targets of from 11 in. to about 35½ in. in thickness. In no case were the plates perforated or materially injured. The projectiles uniformly broke up. At the close of the trials the adaptability of cast-iron used in heavy masses for purposes of defense was clearly established, and sufficient data had been obtained to determine the thickness of metal necessary to resist a given energy of impact of any gun or kind of projectile then in use.

From 1874 to 1882 no new experiments were had. But by the last date not only had the caliber of guns greatly and the striking energy of projectiles enormously increased, but with the latter, hardened steel had taken the place of the chilled iron formerly in use. To settle the questions raised by the improvements in guns and projectiles, a new series of experiments, 10 in number, were undertaken between 1882 and 1885. In these later experiments, guns of from 5.9 in. caliber to the 16.9-in. 100-ton Armstrong were pitted against glacis and turret-plates of from about 15 to 50 in. in thickness. Shot, weighted and empty shell of hardened steel were used. In no case were the targets breached except in a single case each of a turret and a glacis plate. A turret plate of 41.73 in. was breached in four rounds by a 12-in. Krupp rifle, firing empty shell of nearly 1,000 lbs. weight, and with a striking energy of over 14,000 foot-tons. In the other case, a glacis plate of 27.56 in. was breached by the same gun and under much the same conditions. In both of these instances the supporting masonry gave way, placing the target at great disadvantage.

The most interesting experiment was in 1886, when the 100-ton muzzle-loading Armstrong rifle, firing a Krupp steel shell weighted with lead and sand to 2,205 lbs., and having a striking energy of 47.481 foot-tons, was matched against a fac-simile of the Spezzia turrets, above referred to, the armor having a maximum radial thickness of 49 21 in. Fired at short range, not only this, but a St. Chamond steel shot of the same weight failed either to get through or to destroy the target. This record is the more important in view of the fact that two years before, at a competitive trial, upon the same ground, between a Cammel and a Brown compound, and a Schneider all-steel plate, each about 19 in. in thickness, the 100-ton B. L. gun had, at the first round, sent an 1,800 lbs. Krupp steel projectile through each of these plates, with a considerable surplus of energy in each case.

In connection with the experiments with cast-iron armor-plate, it is interesting to note the behavior of projectiles when brought in contact with this class of armor. Upon the target the effect was often nothing more than a bright splash or a slight indent the fraction of an inch in depth. In a few cases a depth of something over 2 in. was obtained. Upon the projectiles, shot and shell alike, the effect was uniform—they flew into pieces like glass; usually the head and point were showered in shapeless atoms, colored blue by heat, while the cylindrical part would be broken into many fragments. In the Spezzia experiments the heated fragments were hot enough to set fire to the timber balks behind the plates. Flat-headed shot were found more effective than pointed ones; empty shell did better work than those weighted with sand.

(TO BE CONTINUED.)

AN ENGLISH LOCOMOTIVE FOR LOCAL WORK.

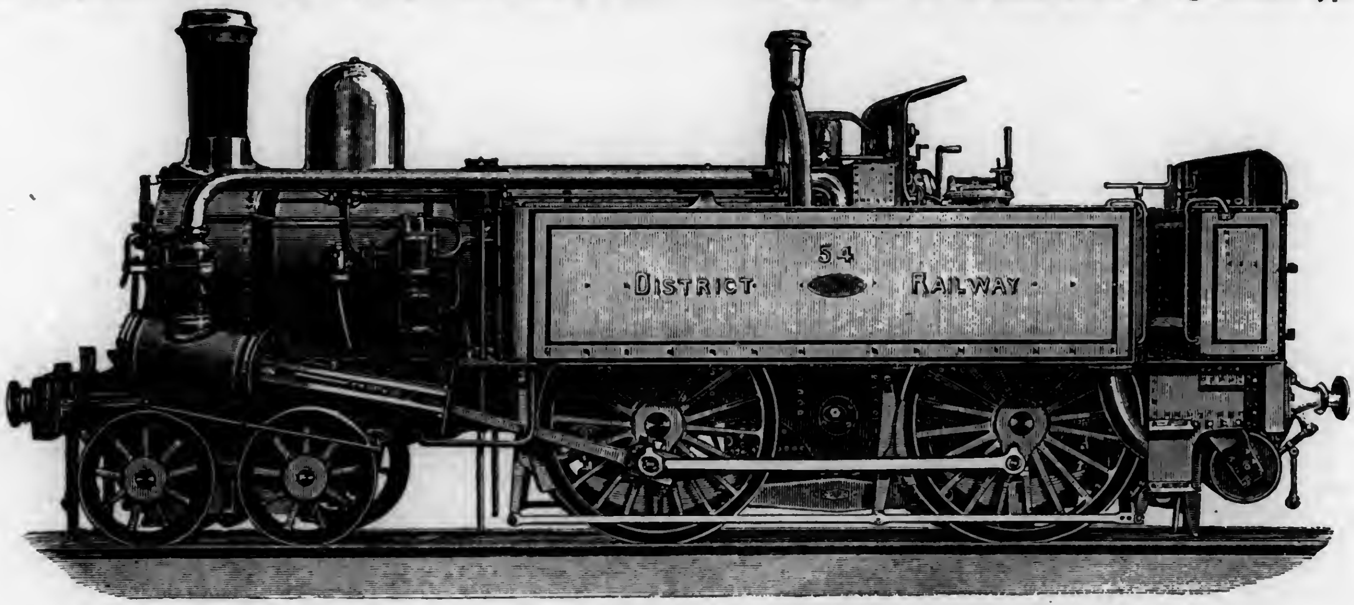
THE accompanying illustration, from the London *Railway Press*, shows the latest locomotive for the Metropolitan District (underground) Railway in London. It is of the same general type as all the engines in use on that road, but includes the latest improvements made. The original type was designed for the underground service by Sir John Fowler, and the engine illustrated was built by Beyer, Peacock & Company in Manchester.

The engine, it will be seen, is of the eight-wheel type with four drivers coupled and a four-wheel truck, water being carried in two wing tanks, and coal in a bunker at the back of the foot-board. The boiler of this engine is 48 in. in diameter of barrel, and has 164 tubes 2 in. in diameter and 10 ft. 6⅝ in. in length. There are two tanks, each 15 ft. 6 in. in length and 3 ft. 6 in. in height, with a total capacity of 1,200 gals. of water. The coal bunker when full will hold about 3,000 lbs. of coal. The total heating surface is: Fire box, 90 sq. ft.; tubes, 903 sq. ft.; total, 993 sq. ft. The grate area is 15.7 sq. ft.

The cylinders are 17 in. in diameter and 24 in. stroke, and are placed outside, with the steam-chests inside in the smoke-box. The steam-ports are 13½ × 1⅝ in. and the exhaust-ports 13½ × 2⅝ in. The valves have ⅞ in. lap and the eccentrics 2⅝ in. throw, the valve motion being the ordinary link.

The driving-wheels are 69½ in. in diameter. The truck-wheels are 36 in. in diameter. The total wheel-base of the engine is 20 ft. 9 in. The total weight of the engine in working order is 104,200 lbs., of which 79,900 lbs. are carried upon the driving-wheels. While running in the open air, the exhaust steam passes through the smoke-stack in the ordinary way, but running in tunnels it is carried back into the tank by the pipe extending backward from the steam-chest, as shown in the engraving.

The engines illustrated are employed on what is known as the "Inner Circle" line. This is 13 miles in length, and in running it 27 stops at stations are required, in addition to which there are generally two or three required by signals. The maximum grade is 1 in 40; there is also an-



LOCOMOTIVE FOR THE METROPOLITAN DISTRICT RAILWAY, LONDON.

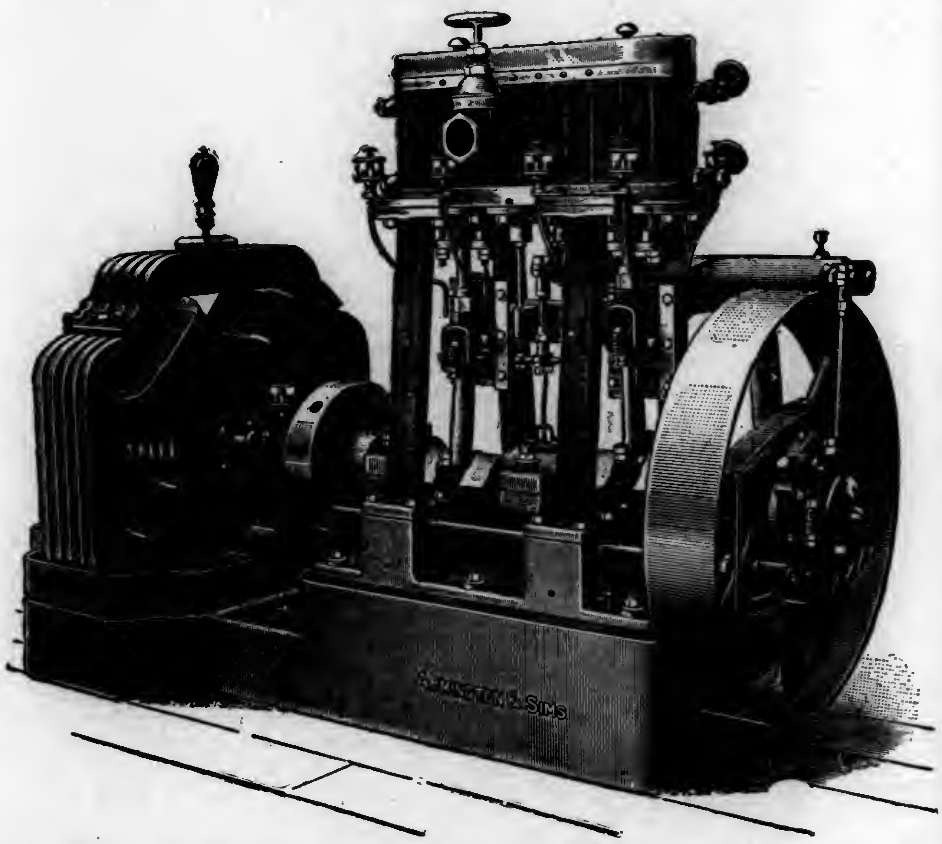
other grade 1 in 45, besides several others varying between 1 in 62 and 1 in 75. The usual train is nine cars, weighing from 75 to 87 tons empty. Almost the entire line consists of curves, the tangents being very short.

For the half year ending December 31 last, the average number of miles run per engine was 15,762, or 2,627 miles per month. They are generally kept steadily at work throughout the day, being in the engine-house one day out of seven. The average coal consumption for the six months mentioned was about 30 lbs. per mile. It may be mentioned that the average time of trains in making the run of 13 miles is 68 minutes, or a little over 11½ miles an hour, including stops. The engines are fitted with the Westinghouse air-brake, including driver brakes, the air-pump being placed forward of the tank, as shown.

UNITED STATES NAVAL PROGRESS.

THE accompanying illustration, for which we are indebted to the *Electrical World*, shows the plant constructed to run the incandescent lights and the search-light on the dynamite cruiser *Vesuvius*.

The engine and dynamo are mounted on the same baseplate, the connection being made by a flexible Brotherhood coupling. The engine is of the Armington & Sims vertical direct-acting type, with two cylinders, each 5 in. in diameter and 7 in. stroke, the crank-pins being set 180° apart. It is provided with a fly-wheel governor, as shown in the cut. The initial pressure of steam is 60 to 70 lbs., so that a reducing valve is used, the pressure on the ship's boilers being considerably higher. The engine is built to cut off between one-third and one-fourth stroke, and can exhaust into a vacuum or directly into the air. The latest improved lubricating cups are fitted to all journals, both moving and stationary; oil-guards are provided, and the oil-tight base receives the drip, from which it can be drawn off by a suitable cock. The shaft has three bearings, one between the cranks and one on either side, and is built to run at a speed of 500 revolutions per minute.



ELECTRIC LIGHT PLANT FOR THE DYNAMITE CRUISER "VESUVIUS."

The dynamo, which is mounted on the same base, is a Thomson-Houston compound-wound, constant potential generator having a capacity of 50 ampères when generating an electromotive force of 80 volts. It has four poles, the four magnet coils being placed as shown in the cut. Within the magnet coils the iron of the magnetic circuit is not laminated as it is between the coils. The armature is of the Gramme ring type, and, being directly coupled with the engine, makes 500 revolutions per minute when the dynamo is generating its maximum output. The dynamo is both magnetically and electrically insulated from the base by hard rubber bushings and washers about the bolts which hold it in place, and by air space. The insulation from the engine is secured by the leather cushion of the flexible coupling.

The plant was built in accordance with specifications furnished by the Navy Department. The dynamo must have, according to the requirements, not less than 80 per cent. commercial efficiency, and must not be heated more than 60° Fahr. above the surrounding atmosphere after a run of four hours at full load. A variation of only 1½ per cent. from the normal speed of 500 revolutions is allowed to produce the maximum output. In regard to weight, the specifications provided that it should not exceed 1 lb. for every three watts output. The collector is made of hard copper, insulated with mica, with bars 1⅝ in. deep.

The regulation of the engine speed is required to be not more than 2 per cent. when the load is varied from full load to 20 per cent. of the total or when the steam pressure fluctuates from 60 to 100 lbs. while exhausting into the atmosphere. A variation of 5 per cent. is allowed in the speed between no load and the maximum, or when exhausting either into the air or a vacuum with the steam pressure at about 60 lbs. The tests which have been made of the engine have shown that these requirements have been fully met. The weight of the entire plant was limited by the specifications to 3,000 lbs., or about ¾ lb. per watt when working at the maximum output.

The contract for the entire lighting plant was given to the Thomson-Houston Electric Company. The two-wire, metallic return system is used, all wires being lead covered and placed in wooden molding.

The engine and dynamo are certainly an excellent example of a very light and compact plant for service where space and weight are important considerations.

NEW SHIPS.

The gunboat *Concord* has had her preliminary steam trials, and will shortly have her official trials for speed, etc.

The *Philadelphia* has been at the New York Navy Yard, receiving her masts and armament, and will shortly be in service.

Work is already well advanced on the hull of Cruiser No. 7 at the New York Navy Yard, and a considerable force is employed on this vessel; the frames are all in place and much of the plating is on.

At the New York Yard also the *Maine* is making progress. The outside plating is nearly all on, and the ship will be ready to launch in October. The great size and excellent lines of the *Maine* are very apparent in her present condition. The machine shops at the yard are very busy on engine work for the new ships.

The armor of the *Maine* will be put on after she is launched. Her armor-plates, and also the plates for the *Puritan* and the *Terror*—both vessels are under completion at the New York Yard—are being made by the Bethlehem Iron Company.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

XI. PAINTS.

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page* 364.)

WITH the possible exception of oils used for lubricating and burning, perhaps no material which railroad companies have to buy is bought with more uncertainty on the part of the buyer, as to the quality of the material he is buying, than paints. Metal, coal, lumber, etc., are either subject to visible inspection or to fairly easily applied tests, which give some idea of the quality of the material, but oils used for lubricating and burning and paints are nothing like so simple. They may be made up of a very large number of constituents, and when once the different materials are put together it is often extremely difficult, and in general to the ordinary buyer impossible to say by any simple means that the material is what it represents itself to be, and this difficulty is, if we reason correctly, greater in the case of paints than in the case of oils used for lubricating and burning, because there is all the liability of the adulteration of the oil used in the paint which occurs in the case of the oils used for lubricating and burning, and there is also the possibility of inferior pigments and inferior driers being used. It is, perhaps, not too much to say that in paints at the present day there is, in general throughout the country, as much inferior material used as in any branch of the useful arts, and when we say this we do not intend to convey the idea that paint manufacturers are in general doing fraudulent business. Our experience with paint manufacturers is that they are as high-toned and honorable as any other class of business men. The use of inferior materials giving poor paints is partly due to lack of knowledge, partly to the stimulus of competition, and partly to the demands on the part of the public for a cheap material which will make an object look well for the time being, the question of durability being laid aside. There is no difficulty whatever in securing good materials which will give the greatest possible durability, and in every way approve themselves in service, provided consumers are willing to pay the necessary price for these good materials.

One point further. It is quite possible that few people who are unacquainted with the actual facts have any conception of the magnitude of what may be called the "paint problem" on railroads. It is, perhaps, not too strong a statement to make, to say that many of the large railroads expend from one-half to three-quarters of a million dollars per year for paints, including under the name paints oils, varnishes, japans, surfacers, and mixed paints used.

In view of the amount of money involved, and in view of the great chances that the buyer may receive inferior materials when he supposed he was buying good, the necessity for a careful study of the paint problem by the great railroad companies is entirely apparent, and in our laboratory we have devoted considerable time to this question for two or three years. It is fair to say that some of the problems are not yet solved, and that no claim is made that the information given below completely covers the ground. The problem is too large and the length of time required in many cases to get satisfactory solutions is too great to have enabled us as yet to get over the whole ground. Some things, we think, are fairly well worked out, and it is these results which we propose to communicate.

Before beginning to give specifications and to discuss the reasons why, it is possible it would be wise to discuss preliminarily several points in regard to paint in general, since a good many points in the specifications depend on the results obtained by a course of experimentation, and these results apply equally well to more than one paint.

The first question which we will discuss is, What is paint?

In a very broad way paint may be said to be any liquid or semi-liquid substance applied with a brush to protect or give color or gloss, or all three, to surfaces. In this sense both whitewash and varnish might be regarded as paints. We do not at present, however, intend to discuss the question from quite so broad a standpoint. The form in which we propose to discuss the material is more from the standpoint of the composition of the paint, and a better definition for our purposes would be that paint is a material consisting of pigment and liquid, usually applied to surfaces with a brush for purposes of protection and ornament, or to secure artistic results, which liquid, after having undergone certain changes, has the power of holding the pigment to the surface. Briefly, then, for our purposes paint is a mixture of pigment and liquid.

Looked at in this light, a number of interesting questions arise, but these, perhaps, may be grouped around two primary questions—namely, what and how much pigment shall be used, and what and how much liquid shall be used in order to make a satisfactory paint. It is obvious that these two questions open a very large field, and that if we could answer them with perfect satisfaction we would know all we wanted to know about paints. It is also obvious, we think, that these questions are not easy ones to answer, and equally obvious that the requisites or essentials of a good paint must be clearly decided on before we can say what kind of materials shall be used in making the paint, since the result which we want to accomplish will go far toward deciding the materials to be used. We will, therefore, first consider what are the essentials of a good paint.

As we understand the matter, the requisites or essentials of a satisfactory paint are (1) that it shall work properly during its application; (2) that it shall dry with sufficient rapidity, and (3) that it shall have the proper durability. The working qualities of a paint are largely a question of the relative amounts of pigment and liquid, but both the nature of the pigment and the nature of the liquid also have influences. The drying qualities of a paint are largely a function of the kind of liquid used, although the pigment also has an influence to a certain extent. The durability of the paint is a function, both of the nature of the pigment and of the liquid. Each of these points will be discussed in detail further on, and since we are treating the matter of paint from the standpoint of the buyer or user, it is possible the question of durability may be regarded as the most important one. We will, therefore, discuss durability first.

As the result of our studies we are inclined to think the destruction of paint follows from seven causes: First, mechanical injury; second, the action of deleterious gases; third, peeling; fourth, the action of light; fifth, chemical action between the pigment and liquid; sixth, destruction during cleaning; seventh, water.

Of these seven causes, possibly the destruction during cleaning and the action of water are the worst, although all of them have their influence, and there may be cases in which some one of the others is most efficient in producing the destruction of that particular paint at that particular time. We will try to discuss each of these causes a little in detail.

1. *Mechanical injury* is not a very serious cause of deterioration of paint except in certain localities. At the sea-shore it has been recognized for a long time that the

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* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the JOURNAL for December, is on the Work of the Chemist on a Railroad; No. II, in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils; No. VIII, in the July number, on the method of purchasing oils; No. IX, also in the July number, on Hot Box and Lubricating Greases; No. X, in the August number, on Battery Materials. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION of special value in indicating the true character of the materials they must use and buy.

paint was so injured by the sand blown against the buildings, that the durability of the paint was not as great as it otherwise would have been. Also the action of cinders on cars is a recognized cause of deterioration of the paint. Of course the best means of preventing this is apparently to have the paint coating as elastic as possible. The harder or more brittle the coat of paint is, the worse will be the destructive action of either cinders or sand. It seems probable, however, that the mechanical injury, except possibly at the sea-shore, is not a very efficient cause of the destruction of paints.

2. The action of *deleterious gases* is very familiar to those who have studied paints at all. In our experience white lead is the most readily acted on in an injurious way by deleterious gases, and the gas most destructive is sulphuretted hydrogen. It is not at all uncommon to see a building painted with white lead become quite black from the formation of sulphide of lead. Subsequent rains remove the sulphide of lead, and in this way the coating of paint is wasted away. We do not remember to have run across any clearly defined case of the destruction of paint due to noxious gases except sulphuretted hydrogen, and, as said above, white lead is apparently the paint which suffers most severely from this cause. The obvious remedy for the destructive action of deleterious gases is to use, if possible, pigments which are not affected by these gases. We have never demonstrated any deleterious action on the binding material which holds the pigment to the surface, although it is probable that ammonia, which may occur in small amounts in the atmosphere, might have deleterious action on the binding material and possibly in some cases on the pigment.

3. *Peeling.*—It is well recognized that in certain places paints do not adhere well to the surfaces, and it is also well recognized that certain paints do not adhere as well as others. This is a marked characteristic, so far as our experience goes, of white zinc—namely, that it peels. We have never noticed any other pigment which possesses this property in any marked degree. It is difficult to say why this pigment should peel so badly. The most plausible theory which we have ever run across is that the zinc white combines with the oil used in the paint, forming a species of zinc soap, and this zinc soap we know to be a brittle, non-adhesive substance. We do not think this theory has ever been definitely established by experiment, and give it for what it is worth. It is also well known that certain surfaces, notably galvanized iron, do not hold paint. The common appearance of many passenger cars, the roofs of which are covered with galvanized iron, is a striking commentary on this fact. Perhaps no worse material could be used for car roofing, provided it is intended to paint the roof, than galvanized iron. Experiments recently made, continuing three years, show that of six different kinds of paint but one maintained itself over the galvanized iron, and this was a patented paint, the composition of which has not yet been worked out. There is very little doubt but that where ordinary paints must be used galvanized iron is the worst material for car roofing. The reason why galvanized iron does not hold paint has been speculated on quite a little, but we have never yet heard any very satisfactory explanation. The most plausible theory that we know of is that, as is well known, sal ammoniac is used during the process of galvanizing, and that a little basic chloride of zinc is formed on the surface of the metal during the operation of galvanizing, which material, being more or less hygroscopic, repels or prevents close adherence between the paint and the surface. We do not think this theory has ever been established, and regard it as of not very great probability, especially as it is claimed that even sheet zinc, which has never been through the galvanizing bath, likewise does not hold paint well. Apparently the truth is that all paints do not adhere to all metals. Some paints, as above described, adhere pretty well to galvanized iron, and the same paints peel over lead, while those which adhere to lead and tin do not adhere to zinc. No very positive general statement can yet be given, and the field of the adaptability of paint to metal still needs study.

4. *The action of light* on paints is not thoroughly well understood. There seems little doubt but that some of the organic coloring matters used in paints are faded by the action of light. It is also possible that the action of light may facilitate chemical action between the pigment and the liquid. No very positive experiments have ever been made on the action of light more than to discover whether certain pigments were faded by exposure. In general it may be stated that pigments containing organic coloring matter, including coal-tar dyes or coloring matter obtained from dye woods, etc., fade more or less when exposed to the light, and some of them quite rapidly, and that this fading is supposed to be due to the action of light. We do not know that this has been absolutely demonstrated.

5. *Chemical action* between the liquid and pigment is a largely unknown field, but in our judgment is an exceedingly important one. It is well known that the liquid in common use in paints is linseed-oil, and that linseed-oil is capable of saponification. It is also well known by those who are at all familiar with chemistry, that soda and potash are not the only substances which combine with fats to make soap. We may have iron soap, lead soap, manganese soap, and zinc soap, or, indeed, almost any of the bases might be combined with the fat acid of the oil, forming soap. The chemical action which may take place between the liquid and pigment may therefore be a saponification under the influence of the water during a rainfall, and of the heat produced by the sun. It is well known that many of the pigments are simply oxides or hydrates, in the same way that soda and potash are ; notable examples of these are white lead, which is carbonate and hydrate mixed, oxide of zinc, oxide of iron, oxide of lead, in the form of red lead or litharge, oxide of chromium, in the form of chrome green, etc. It is, of course, a query whether these oxides do combine with the oil forming soaps of these various bases. In some cases this combination is at least strongly suspected, although in very few if any cases has it been demonstrated. Assuming that the combination does take place, it is evident that the paint left on the surface after a few years, instead of being a pigment, held to the surface by the liquid, which has undergone certain changes called drying, is in reality a new chemical body, consisting of the constituents of the liquid combined with the pigment, or, in other words, may be a soap. The possibility of the formation of a zinc soap has already been hinted at above. It seems probable likewise that with white lead there may be such a combination, resulting in the formation of a lead soap. It is, of course, impossible in the present state of our knowledge to affirm that these results actually do take place, but there seems strong probability that the deterioration and wasting away of some paints, notably zinc white and white lead, may be due to this cause. Positive experiments made with some of the soaps which are insoluble in water show that they are not at all durable. This is notably the case with lime soap, which makes a varnish which gives an elegant gloss when dissolved in turpentine and applied in the usual way, but which, when exposed to the weather, goes to pieces in a few months. If, therefore, some of the soaps which it is possible may be formed by action between the oil and pigment, as above described, should prove, like lime soap, to be of small durability, the chemical action between the oil and pigment would explain a good deal of the deterioration of paints.

Another possible chance for chemical action between the oil and pigment is in those paints which contain pigments which readily give up oxygen, or which readily break up in the presence of organic matter. It is well known, for example, that hydrated oxide of iron, under certain conditions at least, oxidizes organic matter and destroys it. It is also well known that chromate of lead will readily oxidize organic matter. It is possible still further that Prussian blue, in contact with the oil or other organic matter of the liquid, may undergo decomposition. The well-known tendency of chrome yellows, when used as paints, to turn greenish by exposure, may possibly be accounted for in this way. It will be observed that these things are all spoken of as possibilities. We use these words because we do not think the possible chemical changes between oil and pigment, as already stated once or twice, have been worked out, and therefore we cannot

say that the possibilities mentioned above do actually take place. The probability that such chemical changes may take place is so strong, however, that we should give a good deal of force to this probability in compounding paints, and in all our work in devising formulæ for paints we have constantly borne in mind the possibility of chemical action between the pigment and the liquid, and likewise, so far as our chemical knowledge goes, have tried to avoid such pigments as from their chemical nature may result in any action between the liquid and the pigment. The whole field sadly needs study and investigation, and at present all we can say is we try to use as much pigment which from its nature is chemically inert, and as little pigment that is chemically active, as possible. To our minds the well-known fact that white lead mixed with barytes or other inert material lasts longer than pure white lead, is explained on the supposition that the white lead combines chemically with the oil, forming a chemical body which is not as durable as dried linseed-oil with an inert pigment.

6. *Destruction during cleaning* is certainly a very potent cause of the deterioration of paint. This subject will be discussed somewhat at length when we come to the article on soaps. At present it is perhaps sufficient to say that almost all the binding material of dried paints, including varnish, is more or less acted on by caustic and carbonated alkalies, and, as is well known, very little soap in the market is free from either caustic or carbonated alkalies. The ordinary sal soda, also known as washing soda, which is so commonly used by domestics in houses, either with or without soap, in cleaning paint, is a very potent cause of the destruction of paint. Two or three good cleanings will frequently take a good portion of the paint from a door, and in our experience in car cleaning it is not rare to find the varnish almost wholly destroyed and the paint itself seriously injured as the result of cleaning. Many of the highly recommended detergents of the market are simply mixtures of sal soda with some inert material, and they certainly do take off the dirt with great rapidity, but they also remove the varnish and paint with equal rapidity. Some method of cleaning paint without destroying it is a very great desideratum. We will give our experience on this point and our present practice a little later, satisfying ourselves here with putting on record our belief that the cleaning of paint is one of the most fruitful causes of its destruction.

7. In our belief *Water*, if we lay aside the rapid destruction due to cleaning, as above described, is the most potent cause of deterioration and wasting away of paint. Several instances may be cited which point strongly in this direction. It is well known that the lettering on old sign-boards is perhaps the most durable paint that is exposed of which we have any record. Almost every one will remember old sign boards on which the letters stand out in relief, the paint in the interstices between the letters being gone entirely, and in some cases the wood having vanished to a greater or less extent. On examination it is found in such cases, we believe, that the sign-board was originally covered with several coats of white lead, and that over the white lead lamp-black letters were placed, and that the lamp-black letters have protected not only the paint over which they were applied, but also the wood underneath. This phenomenon, to our minds, is explained by the well-known fact that lamp-black is one of the best substances to repel water that is known. Being somewhat oily or greasy in its nature, and being itself practically indestructible, it preserves whatever is under it from destruction. We are inclined to think this would not be the case if the lamp-black allowed the water to get in underneath it to the white lead.

Again, it is well known that inside painting lasts very much longer than outside painting, largely, we believe, because the outside painting is exposed to rain, while the inside painting is protected. It is true the action of gases and light are more severe on the outside painting than on the inside painting, but we do not think the difference can be accounted for in this way.

There is still further proof that water is very destructive to paint—namely, direct experiments show that dried linseed-oil is not water resistant or water repellent. We made some experiments by coating pieces of glass with ordinary linseed-oil, and allowed them to dry and harden for a couple of weeks. These coated glasses then had water placed upon them, and were covered so that the water would not evaporate. To our astonishment, when we examined the glasses the next morning we found that the dried linseed-oil had soaked up water, and wherever the water had touched it the coating presented the appearance of a shriveled apple. On allowing the water to evaporate the coating dried down again to its place; but it is quite evident that the dried linseed-oil did not repel water, and that under the action of the water disintegration was taking place. Dried linseed-oil containing pigment is a different matter, as will be explained later, and it is also possible that, as time progresses, dried linseed-oil may so change chemically that it is less readily acted on by water. Our experiments do not give definite proof on this point, but we are very strongly convinced that the action of water is, all things considered, the most potent cause in the deterioration and destruction of paints. Indeed, we have already put some study on the question of rendering the paint water-proof, and we know of others who have spent a great deal of time in trying to develop a water-proof coating to go over paints and varnishes. Our belief is that if any good paint could be rendered absolutely water-proof, its durability both in protecting the surface and in appearance would be more than doubled, and we do not at the moment know of any field in which the reward would be more sure and abundant than for some simple device which would render ordinary paints incapable of being acted on by water.

Our belief in the destructive action of water on paint is so strong that we use a water test as a quick method of arriving at the durability of any proposed mixture. It is obvious that if, with experiments on paints, we had to wait five or ten years to demonstrate their durability, it would make the study of the subject so long continued that a lifetime would hardly suffice to solve only a few points, and accordingly, in our first attempts to study this question, we looked around for some means which would give us a quick durability test. After looking over all the possible causes of deterioration, as above described, we decided that water alone was the chief single cause, and, as said above, if a proposed paint or mixture does not stand under water for a period of time without change we regard it as inferior. We really know of no single quick test so good as simply to expose the paint to water for a few hours. It is not at all strange to find as the result of such a test both changes in the shade of the pigment and changes in the integrity of the paint.

It is obvious, we think, from the discussion above that to obtain a paint which will be durable is not so simple a matter, and also that the amount of actual knowledge which we have on the subject of the durability of paints is small compared with the unknown field. To design a paint, if we may use the expression, which will successfully withstand some of the deteriorating causes mentioned above, is not so difficult a matter. For example, to get a paint which will stand mechanical action most successfully, it must be made as elastic as possible by using rather a small proportion of pigment and more of the liquid, and also use the least possible amount of japan and no gums or varnish in the liquid. To make a paint which will successfully stand the action of deleterious gases, use no pigment which will be acted on by the gases which prevail in the locality. To avoid peeling of the paint, use on the surface a paint which experience has shown will adhere to that kind of surface, and avoid those pigments or mixed paints which peel from any surface. Again, to antagonize the action of light on paint, use pigments which do not fade, which is probably the best which can be done at the present moment. To successfully meet chemical action between pigment and liquid, of course chemical knowledge is required; and although the field covered by actual demonstration is yet small, still there is enough known, so that we think certain pigments should be avoided entirely. To successfully withstand destruction during cleaning, such methods of cleaning should be used as will be least injurious to the paint. We will give our best knowledge on this subject later. But to get a paint which

will successfully withstand the destructive action of water is, as has already been hinted at, an enormous field, and but very little positive knowledge has yet been obtained.

One or two points, we think, however, are known. We made the following experiments. Several samples of paint were made, consisting of linseed-oil with a very slight amount of japan and varying amounts of the same pigment. No. 1 was simply linseed-oil and japan alone. No. 2 was the same liquid 90 parts, pigment 10 parts. No. 3 was the same liquid 80 parts, pigment 20 parts. No. 4 was the same liquid 70 parts, pigment 30 parts. No. 5 was the same liquid 60 parts, pigment 40 parts. No. 6 was the same liquid 50 parts, pigment 50 parts. No. 7 was the same liquid 40 parts, pigment 60 parts. All the proportions were by weight. The proportions of liquid and pigment higher than 40 of liquid and 60 of pigment will not spread well with a brush if linseed-oil is the liquid, and the pigment has the specific gravity which is characteristic of ordinary iron oxide paints. Two coats of each of these paints were painted on glass and allowed to dry and harden for two or three weeks. They were then placed side by side, and a small portion of the surface of each covered with a globule of water. This globule was covered to prevent evaporation, and the whole thing allowed to stand for 12 to 14 hours. On examination at the end of this time the No. 1 coating was found to have cleaved off from the glass and become shriveled wherever the water had touched it. Apparently the dried linseed-oil had soaked up water, much as a sponge soaks up water. On allowing the water to evaporate the coating dried down again, but not uniformly, and was apparently weakened in texture. No. 2 showed the same phenomenon, but in less degree; No. 3 the same, but in still less degree. No. 4 did not cleave off from the glass, but showed where the water had stood. No. 5 showed a spot in the same way, but in less degree than No. 4. No. 6 and No. 7 showed very slight if any action. We are inclined to think, as the result of these experiments, that a large percentage of pigment is one of the things which is essential to secure durability of paints. Many times we have been asked to use paints which contained very large amounts of coloring matter, the argument being that there was so much of the color that it would bear thinning with a great deal more oil, and therefore would cover a great deal more surface. To our minds the experiments detailed above show that this is fallacious reasoning, and that as much pigment as will give a good spreading paint is a strong element in the durability of the paint.

One point further only. The quantity of pigment present apparently has an influence in protecting the paint against water. Also we are confident the nature of the pigment is a powerful element in protecting the paint against water, and in proof of this we point to the action of lamp-black, as already cited. These two points—namely, amount of pigment and kind of pigment, are, so far as our knowledge goes, the most definite knowledge that we have as to how to preserve paints against the action of water.

In addition to the fact mentioned above, that freshly dried-linseed oil not only does not repel water, but actually soaks it up, it seems probable that the ammonia in the air, as previously mentioned, and which is brought down by the rains, may be a potent cause of the gradual wasting away of paints, since it is well known that ammonia dissolves not only varnish, but also dried linseed-oil, quite readily. It would probably be too much to say to claim, as has been suggested, that the destructive action of rain-water on paints is principally caused by the ammonia that the rain water contains, but we cannot but feel that the slow wasting away of good paints, which have been hardened by age, is at least facilitated by this cause.

The specifications, which we will give later, for certain paints will show how we have studied the problem, and what measures we have taken to antagonize the various deteriorating causes.

In the next article we will discuss the other two points of the essentials of a paint—namely, rapidity of drying and proper working under the brush, and then take up the questions of what and how much liquid to use, and what and how much pigment to use

(TO BE CONTINUED.)

AËRIAL NAVIGATION AND WIND PRESSURE.

To the Editor of the Railroad and Engineering Journal:

IN the interesting and instructive paper on Aërial Navigation in the July issue of your JOURNAL, the statement is made that according to the experiments of Hutton and of Borda, "The resistance of a sphere is 41 per cent. of that of a flat surface of area equal to its mid-section."

Several years ago, while acting as Consulting Engineer of the large and fine Capitol building at Des Moines, Ia., and not being able to find in print or elsewhere the facts needed, the writer considered the subject of wind pressure upon spherical, cylindrical and conical surfaces with a view to finding the effect of the wind upon the hemispherical dome of the building referred to. This discussion was a few years afterward somewhat enlarged by comparing Duchemin's hypothesis with his own, and was published in *Van Nostrand's Engineering Magazine*.

In this discussion the normal pressure; the x, y and z components of that pressure; the moments of these components; the points of application of their resultants; the shearing strain between the dome and the superstructure, etc., are found. It is shown, for example, that the wind tends to distort the dome laterally and vertically, but not in the direction of the wind, and the forces which produce the distortion are computed. Adopting the hypothesis of Duchemin, it is found that the resistance of a sphere is 0.6136 of that of a flat surface of area equal to its mid-section According to the hypothesis of the writer it is found that the resistance of the sphere is 0.6666 of that of a flat surface of area equal to its mid-section. It follows that the resistance of a sphere is, according to the hypothesis adopted, 0.3068 or 0.3333 of that of a flat surface of area equal to the area of the surface of the hemisphere exposed to the wind.

Since the article referred to gives the wind pressure upon cylindrical and conical surfaces, and by implication upon any surface, it is believed to be convenient in connection with the designing of balloons, towers, stand-pipes, etc., as therein pointed out.

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A PROBLEM IN LAND SURVEYING.

BY F. HODGMAN, C.E.

TO *correct a random traverse of several courses between two known points.*

Desired, a general solution which shall be the best for practical application in the field; also the results of such a solution as applied to the example given below.

Example.—A highway between nearest known points is described as follows:

1st.	N. 62° E.,	14.00 chains.
2d.	N. 43½° E.,	8.00 "
3d.	N. 5° W.,	12.00 "
4th.	N. 72½° E.,	10.25 "
5th.	S. 12° W.,	6.43 "

A random run with variation of needle 2° 17′ E. came out 62 links east of the point. Stakes were set at the angles of the random.

1. What is the variation of the needle as referred to the meridian of the original survey of the highway?

2. How much, and in what direction, must the stakes in the angles of the random be moved, to place them in the angles of the original line?

Answers to this problem from readers of the JOURNAL will be acceptable.

Swimming Gloves.—A Spanish gentleman has, according to the London *Drapers' Record*, patented an invention relating to the manufacture of gloves having webs between the fingers, like those on the feet of water-fowl, so that on spreading out the fingers during the propelling stroke in swimming, a comparatively large surface will be presented to the water, and consequently the propelling action will be greatly increased.

THE ESSENTIALS OF MECHANICAL DRAWING.

By M. N. Forney.

(*Continued from page* 374.)

CHAPTER V.—(*Continued.*)

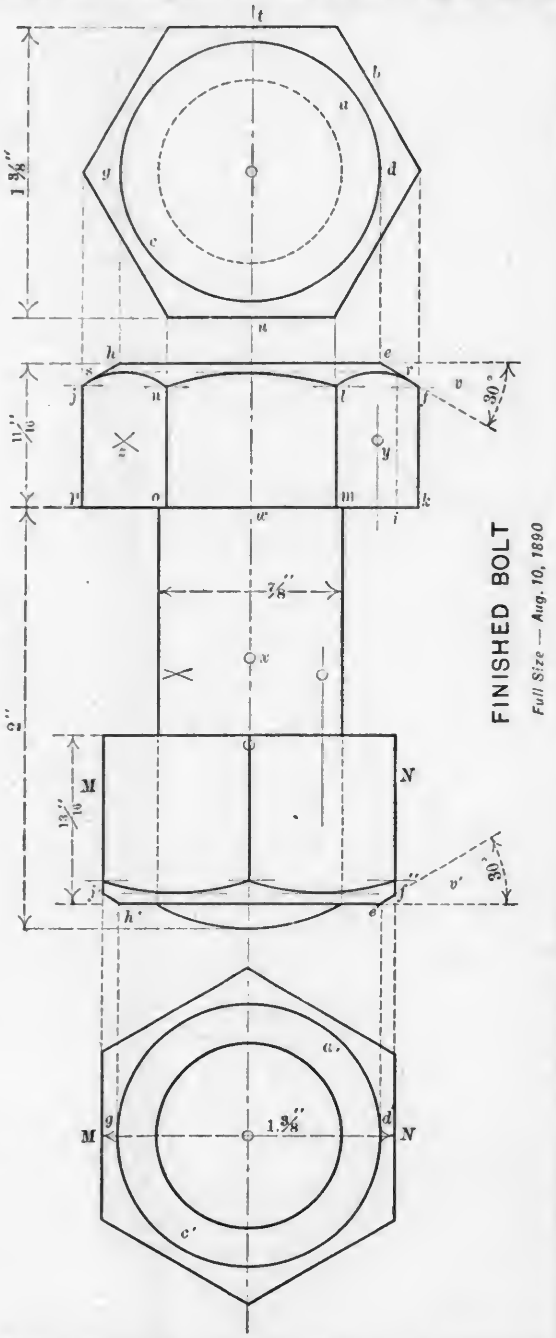
ELEMENTARY PRACTICE.

Bolts such as have been represented in the examples given last month are generally finished—that is, the shanks, ends, tops and bottoms are turned off in a lathe, screw threads are cut on the shanks, the sides of the heads are filed or finished in a machine, and a nut is screwed on the thread. Figs. 141–143

Fig. 141.

Fig. 142.

Fig. 143.



represent a finished bolt and nut drawn full size. In turning it its diameter has been reduced from 1″ to ⅞″, and all the dimensions of the head have been diminished by taking off a part of the metal in finishing. The thread is not drawn in the bolt, but the method of doing it will be explained in a future chapter. No further explanation of the method of making the drawing is needed except to explain how the chamfer or bevel on the top of the head and nut is represented. The top corners of bolt heads and nuts which are finished are usually beveled off to improve their appearance and to make the corners less prominent. Usually the bevel is carried in a short distance inside of the sides of the head or nut, as shown at *a*, fig. 141. The incline *e f* and *e′ f′* of the bevel is generally about 30° with the top of the head, which is indicated by dotted lines at *v* and *v′*, fig. 142. To represent it on the plan of the head and nut, all we need do is to draw circles 3 *a c* and *a′ c′*, figs. 141 and 142, the required distance, inside of the sides of the head. In the side view, fig. 142, the problem is a little more complicated. If with a triangle we draw perpendicular lines, *d e* and *g h*, tangent to the circle *a c*, and extend or "project" them down to the top, *h e*, of the head, then *h* and *e* will be the points of beginning of the bevel *e f* and *h j*, which may be drawn with a 30° triangle.

If the learner will take a bolt head or nut which has been chamfered in this way he will find that in the side view lines are shown where the beveled surface intersects the sides of the head. To show these lines with absolute correctness is a somewhat complicated problem, but the following method gives results which are correct enough for practical purposes: In the side view, fig. 142, which represents the head across the corners, draw the bevel *e f*, as explained. Then from the intersection of the bevel, *e f*, with the corner *f k*, draw horizontal lines intersecting at *l n* and *j* the vertical lines *l m*, *n o* and *j p*, which represent the corners of the head. Next draw a perpendicular

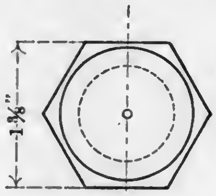


Fig. 144.

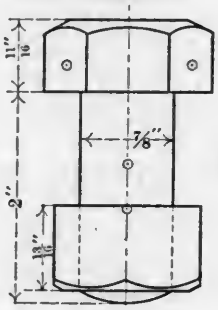


Fig. 145.

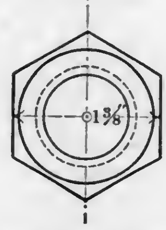


Fig. 146.

line, *r i*, at a distance, *i w*, from the vertical center-line equal to one-half the width or diameter, *t u*, of the head = $\frac{11}{16}$ in. From the point of intersection *r* of *r i* with the bevel *e f*, draw a horizontal pencil line *r s*. Then by drawing arcs of circles, *f l*, *l n* and *n j*, tangent to *r s* and passing through the points *f l n* and *j*, they will represent the lines of intersection of the beveled surface with the sides of the head. The center *x* of the curve *l n* is on the center-line of the bolt, and it and the radius may be found by trial. To get the centers *y* and *z* and radius of the curves *f l* and *n j*, draw a vertical pencil line at *y* half way between *l m* and *f k*. Then by trial get a radius whose arc will pass through *l* and *f* and be tangent to *r s*. With this radius, and *n* and *j* as centers, describe intersecting arcs at *z*, which will give the center of *n j*.

From figs. 142 and 143 it will be seen that the nut *N*, instead of being represented "across the corners," as it is called, is shown in fig. 142, with two of its sides, *M* and *N*, parallel with the "line of vision," or with the direction in which a person is supposed to be looking at the bolt. Therefore, only two of its sides are shown, instead of the three which are seen in the side view of the head. To show the bevel on the nut, the points *e′* and *h′* are located in fig. 142 by drawing a line *e′ d′* tangent to the circle *c′ a′*, as explained above. The bevels *e′ f′* and *h′ j′*, and their curved intersections with the sides of the nut, are then drawn in fig. 142, in the same way as has been described for drawing the head.

As remarked above, the screw-thread of the bolt is not shown in the engravings. To represent it correctly is a difficult problem, which will be explained in a future chapter. Gener-

ally, in making working drawings of bolts, it is sufficient to show the bolt where it passes through the nut by dotted lines, as in fig. 142.

Figs. 144-146 represent the bolt drawn to a scale of 6 in. = 1 ft., or "half size." It will be good practice for the learner to draw the bolt both sizes, so as to familiarize himself with the use of different scales.

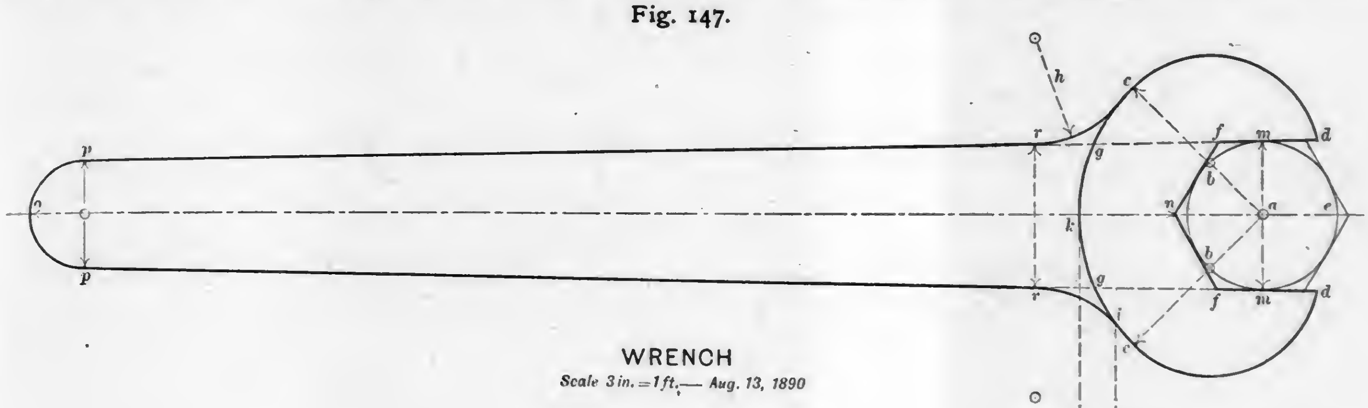
WRENCH.

Figs. 147 and 148 represent a common wrench, half size. To draw this, the first thing to be done is to lay down a center line *e o*. From some point, *a*, as a center, near the end of the line, draw a circle *e b b*, whose diameter, *m m*, is equal to the width of the bolt-head or nut measured across its sides, or its *short diameter*, as it is called. Circumscribe this circle with a hexagon, as shown. In order to hold the nut securely, the wrench should project slightly beyond the corners of the nut at *d d*. Having laid down these two points, draw lines *a c* and *a c* through *a*, and at 45° with *e o*; then *b b*, the points of intersection of these lines with the circle, will be the centers of the curves *c d*, *c d*, which should be drawn through *d* and *d* with a radius *b d*. Another curve, *c k c*, should then be drawn from the center *a* with a radius *a c*, and tangent to *c d* and *c d*. The length of the handle of the wrench from *n* to *o* should be about eight times the width *m m* of the nut. The width *p p*, at the end of the handle, should be three-quarters the width of the nut. Having laid off the length of the handle from *n* to *o*, draw a semicircle *p o p* through *o*, and extend the lines *d f*, *d f*, so as to intersect *c k c* at *g*, *g*. Then, from *g*, *g*, draw lines *g p*, *g p*, tangent to the semicircle, and with a radius *h* = *b c* draw curves *c r*, *c r*, tangent to *c k c* and *r o*.

To draw the wrench looking at it edgewise, first lay down a center line *D d*, fig. 148. For the thickness *C* of the head of the wrench, take three-fourths of the thickness of the nut measured lengthwise to its bolt. Lay this off from the center-line *D d*. *D*, the thickness of the handle, should be one-half as much as the head, which should be laid off in the same way.

To draw the curves which unite the head with the handle of the wrench, draw a line *i j* from *i*, in fig. 147, where the curve *r c* joins *c k c*. Then, from *j* and *j'*, where *i j* intersects the sides of the head, draw curves tangent to the sides of the handle. A similar method should be followed to show, on fig. 148, the curves *l r* and *l' r'* formed where the handle joins the head at *k*, fig. 147.

Fig. 147.



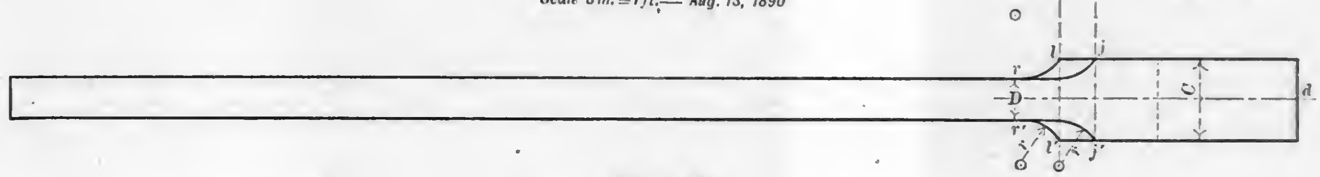
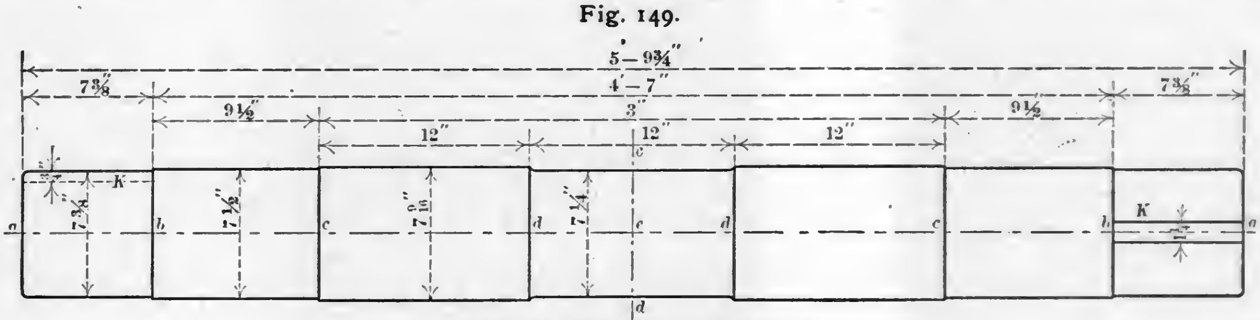


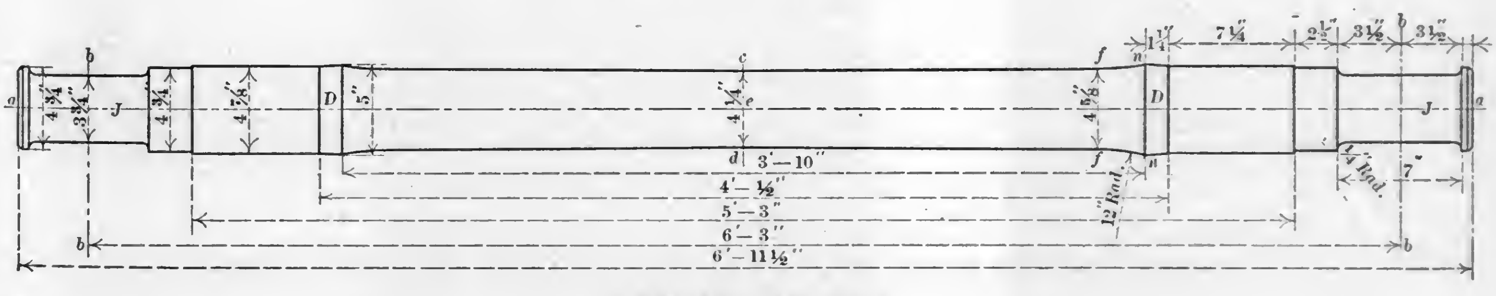
Fig. 148.

Fig. 149.



LOCOMOTIVE DRIVING AXLE

Scale 1 in. = 1 ft.— Aug. 13, 1890



STANDARD CAR AXLE

Scale 1 in. = 1 ft.— Aug. 13, 1890

Fig. 150.

LOCOMOTIVE AND CAR-AXLES.

Figs. 149 and 150 represent respectively a locomotive driving-axle and one of the standard car-axles recommended for general use by the Master Car Builders' Association. The learner is recommended to draw this to a scale of 3 in. = 1 ft. To do this, horizontal center lines *a a* and *a a* should first be laid down. These should be bisected by vertical center lines *c d* and *c d*. From *e*, the intersection of these two lines, lay off on each side of it in fig. 149 half the total length *a a* of the axle, and half the distance of the shoulders *b, b, c, c*, and *d, d* from the same point. Draw vertical lines through these points, representing these shoulders. Then, from the center line *a a* lay off on the vertical lines half the diameters between the shoulders, and draw horizontal lines connecting the vertical lines which represent the shoulders. *K*, on the right-hand end of the axle, represents a key seat which is 1¼ in. wide and ⅜ in. deep. The key-seat at the opposite or left-hand end of the axle is placed at right angles to the other one, because the driving-wheels of a locomotive are fastened to the axle in such a position that their cranks will be at right angles to each other.

In drawing the car-axle, it is best to lay off on each side of *e* half the distance between the vertical center lines *b b, b b*, which pass through the middle of the journals, *J, J*, as it is more important that this measurement should be correct than that the total length should be right. Having drawn the vertical lines *b b, b b*, lay off the length and diameter of the journals and the collars *a a*, and draw the lines representing them. It will be noticed that where the journals join the collars and the shoulders on the axle that the corners are rounded. These curves should be drawn with a radius of ¼".

It will be seen that the shoulders *D, D* are tapered or conical in shape, and that where they join the central part of the axle, its outline is curved. Where the curved portion joins the part which has a straight outline, the axle is 4⅝" diameter. To draw these curves, draw lines through *f f* parallel to *a a* and 4⅝" apart. Then through *n n*, the extremities of the inside line of the shoulder *D*, draw curves, with a radius of 12", which will also be tangent to the parallel lines drawn through *f f*. Lay off the middle diameter of the axle on the line *c d*, and draw lines *c f* and *d f*, which must be tangent to the curves *f n, f n*.

Having drawn the outlines of the two axles, all the important dimensions should be given in figures on the drawing. It should be remembered by the learner that every dimension which he requires to draw the axle will be needed by the mechanic who forges or finishes it, and therefore they should all be marked on the drawing, as has already been explained. No general directions for doing this can be given. In drawings of objects with two ends alike similar to the two axles, it is best to mark the dimensions of length on one end of the drawing, and the cross measurements on the other end. If the dimensions or dimension lines are liable to confuse the drawing, the latter should be carried out to one side of the drawing, as has been done in a number of the examples. The student can be guided by the engravings, but it should be noticed that it is essential to give not only the short dimensions, as the distance between the shoulders of the axle, but also the distances *over all*, and these *must* agree with each other.

MISTAKES.

The learner should keep in mind that the most inexcusable fault in a draftsman is a mistake. No other merit will atone for making blunders. They are expensive and always annoying, and no repentance over the consequences of errors will defray their cost or fully restore the reputation for carelessness which the person who has made them has acquired. A draftsman must, therefore, be constantly vigilant to avoid mistakes. He should exercise the utmost care in making his drawings and in marking the dimensions on them, and should check them off in every possible way, which will help him to discover discrepancies. A common source of such misfortunes, which nearly every young draftsman has to do bitter penance for, is mistaking a figure 6 on his rule or scale for a 9 or a 9 for a 6 when they are upside down.

An excellent way to detect errors is to go over the whole drawing when it has been "penciled in," and remeasure every dimension to see whether it is right. After the drawing is inked in, mark the dimensions on it, and when these are all on the drawing, remeasure the whole drawing with a scale and see whether the figures and measurements correspond with each other. If the sum of a number of dimensions is given, add them together and see whether the long dimensions agree with the calculation. Thus, in fig. 149 add together all the distances between the ends *a a* of the axle and the shoulders *b b*, and between the shoulders *c c* and *d d*, and see whether the total distances between *a a, b b* and *c c* are the same as the sums of the short dimensions. If any of the figures have been obtained by calculations, always go over the computations a second time when the drawing is finished. It is impossible to place too much emphasis on the importance of a draftsman being sure he is right. No lingering doubt about the correctness of a drawing should be tolerated by the person who makes it, and every means of knowing he is right that is available to a human being should be employed to guard against errors. A draftsman should always keep in mind the maxim that "THINGS WHICH ARE NOT QUITE SURE ARE VERY UNCERTAIN."

Fig. 151.

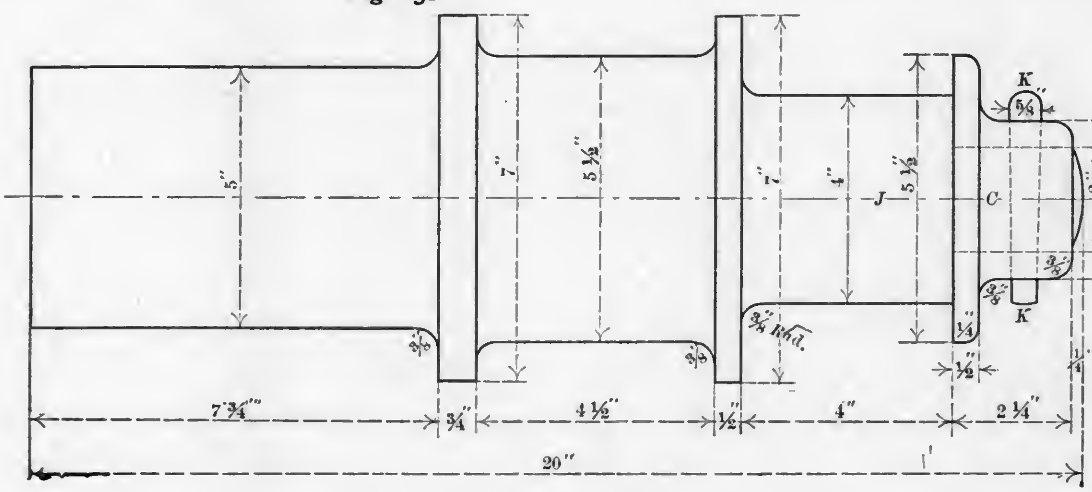
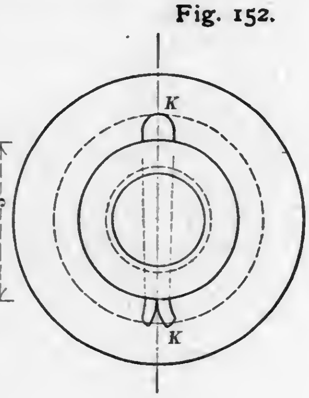


Fig. 152.



LOCOMOTIVE CRANK-PIN

Scale 3 in. = 1 ft. — Aug. 13, 1890

CRANK-PIN.

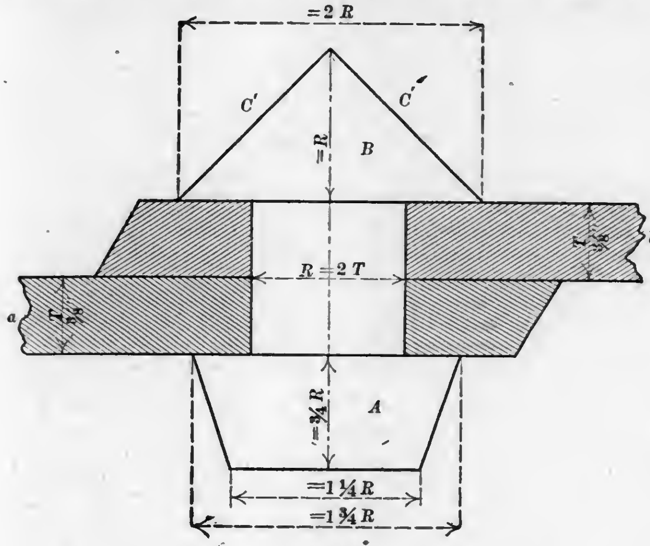
The preceding directions make little additional instruction necessary to enable the learner to draw the crank-pin shown by figs. 151 and 152. It should be drawn either half or full size. *C* is a collar which is screwed on the end of the pin to hold the coupling-rod on the journal *J*. The tapered pin or key *K K* passes through the collar and the screw to prevent the collar from unscrewing. The lower end of the key is split, and the two parts are bent apart, as shown in fig. 152, to hold the key in its place.

ARROW HEADS.

In figs. 125–139, given last month, the arrow-heads on the dimension lines are represented as though they were drawn "by hand" with an ordinary writing pen. In the illustrations given this month, it will be noticed that the arrow-heads are drawn with a pair of spring-compasses, which gives the drawing a much neater appearance. Either method may be used, but if neatness is aimed at, the compasses should be used in doing this work.

RIVETS.

When two metal plates or flat bars are to be fastened together, the simplest way of doing it is with rivets. The plates or bars are made to overlap each other, and holes are either drilled or punched in them to receive the rivets. They are made with a



RIVET
Full Size
Fig. 153.

round enlargement, *A*, fig. 153, on one end, which is called the *tail* of the rivet. When used the rivets are heated red hot and are placed in the holes in the plates, and a second enlargement, *B*, fig. 153, called the *head* of the rivet, is formed on the other end, either by hammering by hand or by pressure between the two dies of a machine.

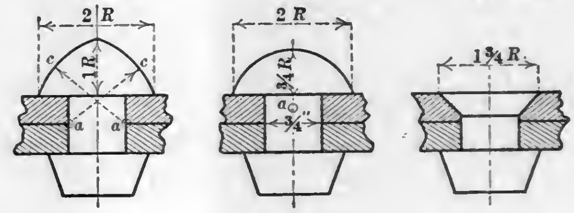
Experimental and theoretical investigations have shown that to get the greatest strength in a riveted joint the diameter and the distance apart of the rivets must bear a certain relation to the thickness of the plates which are held together, and that the heads and the tails should have certain proportions to the diameter of the rivet.

Fig. 153 represents an outside view of the ordinary form of rivet drawn full size. The shaded areas on each side represent sections of a portion of the plates. This is a common way of drawing sectional views which pass through the centers of rivets, bolts, shafts, rods, etc., as will appear in future illustrations. The irregular lines at *a* and *b* indicate that only portions of the plates are shown, and they are supposed to be broken off at these points. This is also a usual method of representing a part only of any object in a drawing.

It has been found that to secure the greatest strength in a lap seam or joint, the diameter of the rivets should be equal to twice the thickness of the plates. In fig. 153 the thickness of the plates is indicated by T and is equal to ⅜ in. The diameter of the rivet is indicated by R, and is equal to 2 T, or ¾ in.

The tail A of a rivet is usually made of the form shown in the

Fig. 154. Fig. 155. Fig. 156.



RIVETS
Scale ⅜ in. = 1 in.

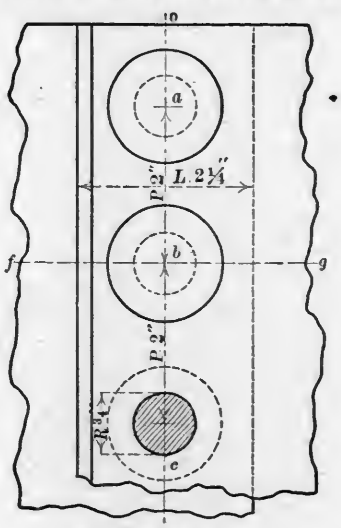
engraving, which is called a *frustrum of a cone*. Its flat end facilitates holding the rivet in the holes, while the heads are being formed.

The head B, shown in fig. 153, is cone-shaped. This is a usual form of rivet heads which are made by hand. The thickness of the tail A is equal to ¾ the diameter, or, as written in the engraving, = ¾ R. The large diameter of the tail = 1¾ R, and the small diameter = 1¼ R. The diameter of the head B = 2 R, and its height or depth = R. This makes the angle of its sides C' C' 45° to a perpendicular or horizontal line.

The student should draw the rivet as shown in the engraving, and then from the rules given should design and draw rivets for plates ¼ and ½ in. thick.

In doing this, center lines should first be drawn as described for drawing a bolt, and the thickness of the heads and the tails and their diameters should be laid off from these lines.

Fig. 157.



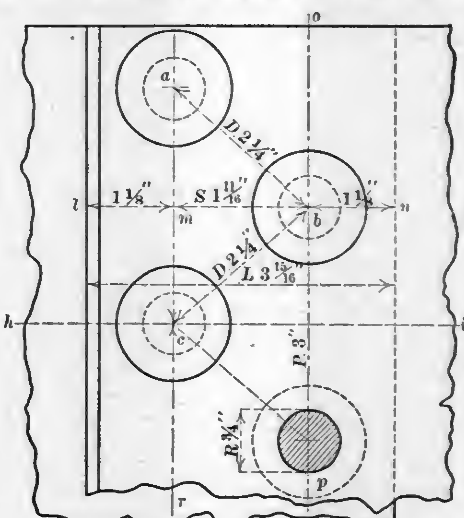
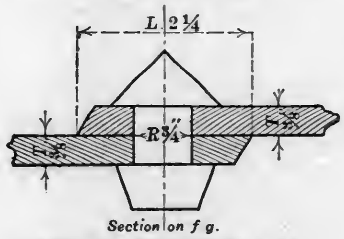


Fig. 159.

Fig. 158.



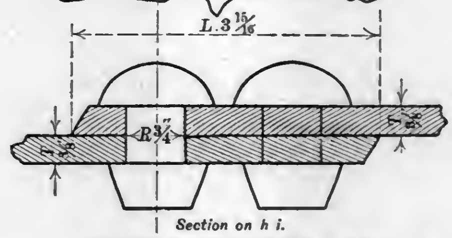


Fig. 160.

SINGLE RIVETED LAP BOILER SEAM

DOUBLE RIVETED LAP BOILER SEAM

Scale ¼ in. = 1 in.

Various forms of rivet heads are used. Fig. 154 shows on a smaller scale what may be called a *Gothic head*, which cannot be readily made by hand, but requires a die to form it. It is somewhat stronger than a conical head. Its diameter and depth are the same as for a conical head. Centers *a a* should be found

on the edges of the p'ates which are in contact, from which, with a radius *a c*, *a c*, arcs may be drawn to form the outline of the head.

Fig. 155 represents a rivet with a *button-head.* Its diameter is also equal to twice that of the rivet, and its depth = ¾ *R*. Its outline may be drawn from a center on the center-line of the rivet with a radius which is easily found by trial after the diameter and height of the head is laid down.

In fig. 156 a countersunk head is shown. This form is only used when a projecting head would be in the way of some other object in contact with the plates, as a flange or bar. It is not as strong as the other forms of heads, and the countersink weakens the plate. Its diameter = 1½ *R* and its sides have an angle of 45°, which determine its depth. The student should draw each of these rivets full size.

It may be remarked here that the heads and tails of rivets are generally made too small to give the greatest strength to a riveted seam. Large heads also hold the plates together better than small ones, and thus keep them water and steam-tight.

SECTION LINES.

In drawing the section lines, which represent the surface of the bisected plates, the learner must endeavor to get them all as near the same distance apart as possible. He should not attempt to draw them too close together, as to do this increases the work very much, and any inaccuracy in their distance apart is more apparent when they are near together than it is if they are further apart. If the scale of the drawing is larger than that of the engravings, the section lines should then be further apart than they are in the engravings. Practice and care will teach the young draftsman to draw these lines at uniform distances apart.

BOILER SEAMS.

Fig. 157 is a plan and fig. 158 a section of an ordinary single riveted lap boiler seam. The plates are of the same thickness and the rivets are the same size as are shown in fig. 153.

A center-line *o c* should first be drawn on which the row of rivets *a*, *b*, *c*, is laid out. The distance apart of the rivets, measured between their centers, or their *pitch*, as it is called (which is indicated by *P* in the engraving), is 2 in., or 2⅔ times the diameter of the rivets. The first rivet, *a*, is laid off at a distance *o a* of half the pitch from the edge of the plate. The centers of other rivets, *b* and *c*, are then laid off on the center-line with dividers, by taking the pitch between their points.

The *lap* of the plates—that is, the width of their surfaces in contact (indicated by *L*), is 2¼ in., or equal to 3 times the diameter of the rivets. The learner should draw these two figures and the two following ones full size, and mark all the dimensions on them.

Figs. 159 and 160 represent a double-riveted lap boiler seam. The rivets of this are arranged in two *zigzag* or *staggered* rows. The object of this is to leave as much strength as possible in the plates between the rivets *a* and *c* and *b* and *p*, while at the same time those in the adjoining rows, as *a* and *b*, are near together, and thus hold the plates securely and keep the joint water or steam-tight.

With this arrangement of rivets the plates must either break on the line *a c r*, *o b p* or on the ziggag line *a b c p*. With the rivets arranged as shown in fig. 159, the plates have more material between the holes to resist rupture than they have if arranged as shown in fig. 157.

The *longitudinal pitch*, as it is called, of the rivets in fig. 159, or their distance apart measured from *a* to *c* or *b* to *p*, is 3 in., or four times the diameter of the rivets. The diagonal pitch, or *a b* (represented by *D*), is 2¼ in., or three times *R*, and the lap *L* 3 15/16 in., or 5¼ *R*. In drawing the plan of this seam, deduct the distance between the two rows of rivets from the lap and take half the remainder, as the distance *l m* and *b n* of the two rows of rivets, from the edges of the plates. Subdivide the pitch *a c*, and from the middle point *m* draw *m b* at right angles to *a c*. The point of intersection *b* with *o p*, the center-line of the second row of rivets, will be the center of the rivet *b*. Or the position of this rivet may be laid down by taking the diagonal pitch *a b* as a radius, and from *a* and *c* as centers describing arcs intersecting at *b*, which will be the center of the rivet. Other rivets, as *p*, may be laid off in the same way. In both figs. 157 and 159 sections through the body of the rivets *p* and *c* are shown, the heads being omitted. This is done to show the size of the body or shank more clearly.

Ordinarily, in a plan of a riveted joint the rivet heads are all omitted, the rivets being represented by circles when diameters are equal to those of the bodies of the rivets.

In cases as at *T T*, in figs. 158 and 160, when the space between the arrow-points is not sufficient to contain the dimensions, they are sometimes placed on the outside of the lines to which they refer, as shown in the figures referred to.

The following rules and table for the proportions of rivets and riveted seams will be found convenient in drawing them. With the exception of those relating to rivet-heads and tails, they have been taken from D. K. Clark's excellent *Manual of Rules and Tables for Mechanical Engineers :*

RULES FOR PROPORTIONING RIVETS AND RIVETED SEAMS FOR IRON AND STEEL PLATES.

T = Thickness of plates	= unity or one
R = Diameter of rivets	= T × 2
Diameter of head of rivet	= R × 2
Height of head of rivet	= R
Large diameter of tail of rivet	= R × 1¾
Small " " " " "	= R × 1¼
Height of tail of rivet	= R × ¾
P = Pitch of rivets (single riveting)	= R × 2⅔
P = " " " (double riveting)	= R × 4
D = Diagonal pitch of rivets (double riveting)	= R × 3
S = Space between two rows of rivets (double riveting)	= R × 2¼
L = Lap of plates (single riveting)	= R × 3
L = " " " (double riveting)	= R × 5¼

TABLE GIVING PROPORTIONS OF SINGLE AND DOUBLE RIVETED LAP RIVETED SEAMS.

T Thickness of Plate.	R Diameter of Rivets.	Pitch of Rivets. P Single Riveting.	Pitch of Rivets. Double Riveting. P Longitudinal.	Pitch of Rivets. Double Riveting. D Diagonal.	Pitch of Rivets. Double Riveting. S Spacing between two Rows of Rivets	Lap of Plates. L Single Riveting.	Lap of Plates. L Double Riveting.
Inch.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
⅛	¼	⅔	1	¾	9/16	¾	1 5/16
3/16	⅜	1	1½	1⅛	27/32	1⅛	2
¼	½	1⅓	2	1½	1⅛	1½	2⅝
5/16	⅝	1⅔	2½	1⅞	1 13/32	1⅞	3¼
⅜	¾	2	3	2¼	1 11/16	2¼	3 15/16
7/16	⅞	2⅓	3½	2⅝	2	2⅝	4⅝
½	1	2⅔	4	3	2¼	3	5¼
9/16	1⅛	3	4½	3⅜	2½	3⅜	5⅞
⅝	1¼	3⅓	5	3¾	2 13/16	3¾	6½
11/16	1⅜	3⅔	5½	4⅛	3 1/16	4⅛	7¼

(TO BE CONTINUED.)

The Corinth Ship Canal.

THIS canal is the subject of an elaborate paper in a recent number of the *Annales des Ponts et Chaussées.*

All the vessels trading between the Mediterranean ports of France, Spain, Italy, and Austria with Greece, Turkey, the Lower Danube, and the Black Sea, are obliged to round Cape Matapan, which forces them to go out of the course about two degrees of latitude to the southward, and, of course, the same distance to the northward again. By cutting through the Isthmus of Corinth, the route for goods from the Adriatic will be reduced by 185 sea-miles, and from the Mediterranean by 95 sea-miles. The toll for traversing the canal will be only 9.6 cents per ton for the Mediterranean trade, 19.2 cents per ton for the Adriatic trade, and 19.2 cents per passenger ; and these tolls have been estimated to attain hardly half the amount which will be saved by shortening the routes. Moreover, the increase in safety, by avoiding the dangers encountered in rounding Cape Matapan, will reduce the rates for insurance. The total tonnage of the vessels rounding Cape Matapan is reckoned at 12,000,000 tons a year, and the Canal Company has estimated at less than half this amount—namely, at about 5,900,000 tons—the traffic which they may rely upon to pass through the canal. The passage of the canal will not be impeded either by the wind or by currents, for it is sheltered on both sides by hills, and the greatest possible difference of water-level in the gulfs at each end would be only 1 ft. 8 in. under exceptional conditions. The canal is being excavated in a straight line, in open cutting, having a length of 3 miles 1,656 yards, and it follows exactly the line of the Emperor Nero's project.

It will reach deep water at both ends about 660 to 990 ft. from the shore. The bottom width of the canal, of 72 ft., and

the depth of 26¼ ft., are the same as on the Suez Canal; but the proposed slopes of 1 in 10 through the rocky portion of the cutting will afford a width at the surface of the water of only 77½ ft., and a cross-section of 2,032 sq. ft., instead of the width of 177 ft., and the cross-section of 3,272 sq. ft. on the Suez Canal. The small section of the canal will be disadvantageous for navigation, owing to the limited space for the reflux of the water displaced by a vessel in its progress. The approach channels at each end are to have a bottom width of 328 ft., and will be protected by rubble stone jetties. The total excavation in the original design was estimated at 12,865,000 cubic yards, including about 2,400,000 cubic yards for slips or eventual enlargements. The nature of the strata had, however, not been sufficiently investigated, reliance having been placed on the indications furnished by the pits opened by Nero, which did not go down the full depth of the cutting, and from which it was conjectured that the strata were compact enough to stand at slopes of 1 in 10. The region is volcanic, and earthquakes are common; and, consequently, it was not surprising that when the cuttings had reached some depth, a large number of faults were encountered, and a considerable disturbance of the layers of deposit of the tertiary strata was revealed. The maximum depth of cutting to the bottom of the canal is 284⅝ ft.; and the mean depth, for a length of 2.6 miles, is 190 ft. With this mean depth, the cutting with slopes of 1 to 1 would involve three times the excavation originally anticipated; but fortunately 1 to 1 slopes will not be necessary for the greater portion of the cutting, so that the amount of actual excavation will probably not exceed 1½ times the estimated quantity. Three methods were devised for excavating the channel: 1. Priestman excavators and dredgers were to remove the alluvial portions adjoining the gulfs on each side, amounting together to 3,270,000 cubic yards in the first year. 2. Special dredgers, constructed for the purpose, were to remove the excavation of the rocky portion, after the rock had been broken up by blasting, to the level of 167⅓ ft. above the bottom of the canal. This excavation, amounting to 7,063,000 cubic yards, was to be effected by the two special dredgers in three years. 3. The cap of the rocky mass above the aforesaid level, comprising 2,616,000 cubic yards, was to be removed by means of dynamite, excavators, and railways. The deep vertical blasting holes did not furnish the expected results, and therefore the special dredgers could not fulfill their object; and the only operations which succeeded were the ordinary dredgings at the entrances to the canal, and the excavation of the rocky cap, carried out in the usual way and removed by wagons. The first period of the works, during which the above system of excavation was adopted, extended from the commencement in April, 1882, to the close of 1884. The rubble jetties and dredgings for forming harbors at each end were carried out during this period. The harbor in the Gulf of Corinth is protected by two converging jetties, 1,310 ft. and 1,640 ft. long respectively, with an entrance between their extremities 262 ft. in width; and one jetty on the northern side affords adequate protection in the Gulf of Athens. The excavations effected to the end of 1884 amounted to only 1,700,000 cubic yards; and the rate of progress afforded no hope of completing the work in 1888 according to the terms of the concession. The works entered upon a second stage when M. Bazaine was appointed Engineer-in-Chief; and he extended largely the employment of wagons and locomotives for the removal of the excavations, and made flatter slopes in places to avoid the slips which were threatened owing to the number of faults. The excavation accomplished in the three years, 1885–87, reached 6,278,000 cubic yards. At the same time, as the cutting was carried down, the nature of the strata became more manifest; and borings to the bottom of the cuttings, together with a geological survey of the whole route, enabled a definite opinion to be formed of the works required. In December, 1889, M. Bazaine reported that the principal indispensable works were: the protection of the sides of the canal with masonry in hydraulic lime or cement mortar for a height of 33 ft., along a length of from 2¼ to 2⅞ miles, to preserve them from erosion; the formation of a bench, not less than 5 ft. wide, on each side of the canal, 6½ ft. above sea-level, to enable the walling to be carried out; and the easing of the slopes at certain parts of the cutting to ensure their stability. He estimated that this scheme would involve 2,355,000 cubic yards additional excavation, and an increase of $2 000,000 in the cost; and he proposed an extension of the time to the end of 1891, and various supplementary works.

A commission of experts has prolonged the extension of time for the works to the end of 1892, and the General Assembly of Greece has granted $3,000,000 for the additional cost and the supplementary works. The total cost of this canal will be about $12,000,000, or about $3,190,000 per mile, the excavation averaging 3,509,000 cubic yards per mile; the cost will thus be about 91 cents per cubic yard excavated.

Recent Patents.

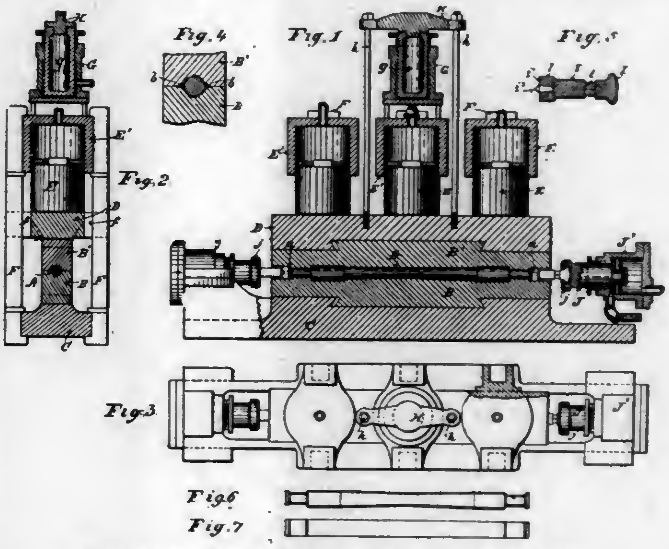
WELLMAN'S APPARATUS FOR FORGING CAR AXLES.

The accompanying illustrations show apparatus for forging car axles, which is covered by Patent No. 422,357, issued to Samuel T. Wellman, of Cleveland, O. Fig. 1 is a side elevation partly in section; fig. 2, a transverse section through the center of the machine; fig. 3, a plan; fig. 4, a cross-section of the dies on a larger scale; fig. 5, the upsetting die; figs. 6 and 7, elevation and plan of blank.

The machine is intended for rounding forged blanks previously prepared. These blanks have two parallel sides, as shown in fig. 7, and are of such variable width as shown in fig. 6, as will distribute the metal lengthwise the same as in the finished forging A, which is shown between the forging dies B B'. The lower die, B, is stationary, being secured to the bed-plate C; the upper die is secured to the head D, to which are attached the plungers E of the water cylinders E'. These three cylinders are supported by heavy side pieces or columns F, one member, f, serving as a guide for the head D. The cylinders are connected so that they operate simultaneously.

Above the central cylinder and supported from the same is a smaller water cylinder G, having the plunger g connected with the cross-head H. The latter in turn is connected by means of rods h with the head D, and by operating this upper ram the die, head and plungers are elevated.

The dies B B' are adapted to fit the finished forging except



WELLMAN'S APPARATUS FOR FORGING AXLES.

that the internal corners at b are cut away, as shown more clearly in fig. 4. The recesses thus formed receive the metal that is forced laterally in breaking down the blank with the first closing of the dies, and prevents the forming of fins, which would stop the dies from closing. Outside the end collar a of the axles the bore of the dies is cylindrical to the end.

By operating the dies B B', the axle is not drawn except at or near the ends, but at the ends the tendency to elongate is such that without other appliances the collars A would not be forged full and sharp, and the ends would be uneven and ragged. To avoid this upsetting dies I are provided, the heads I' being adapted to fit internally the end section of the dies B B'. The enlarged rounded ends I^2 of these upsetting dies enter corresponding sockets in the end of the plungers J of the double-acting rams J'. These are mounted on the ends of the bed-plate C. The dies I are held to fit their seats in the plunger by removable caps j, which fit so loosely that when the dies B B' are open the free ends of the upsetting dies may be raised a short distance. The length of the dies I is such that with the plungers J thrust forward their full throw the axle is upset to just the length required. For axles of different lengths or diameters the dies are changed. The collars a of the axles may be made longer without changing the large dies by substituting shorter upsetting dies and using a blank with more metal in the end.

In operating the apparatus, the blank is placed edgewise between the dies B B' and the dies are closed. At the same time the upsetting dies I are brought forward their full stroke and held in such position. The first stroke of the large dies B' breaks down the blank and fairly shapes the upper and lower section, but leaves ridges along the sides of the axles where the edges of the dies are cut away, as explained above. Next, the

metal, by means of the dies *I*—which have the sections *i* squared to receive a wrench for turning—is given a quarter turn to bring these ridges to the top and bottom. A few more strokes of the dies *B'*, the axle meantime being rotated between the strokes, finish the work, the entire operation requiring only a very short time.

MACHINE FOR ROLLING CAR-WHEELS.

Figs. 8, 9, 10, 11 and 12 show a method and apparatus for making metallic car-wheels, which is covered by patent No. 430,750, issued recently to Samuel H. Ralston and John R. Jones. Their invention consists in producing a car-wheel hav-

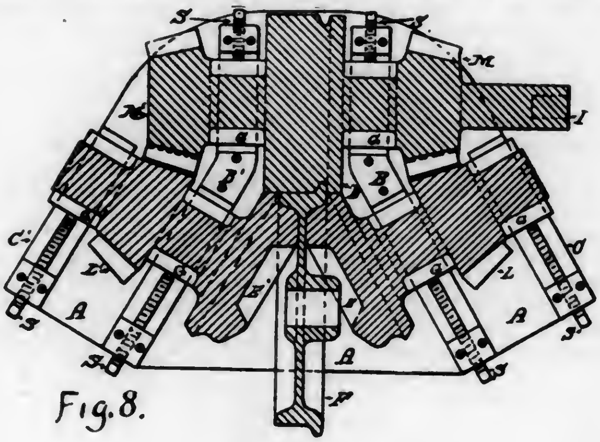


Fig. 8.

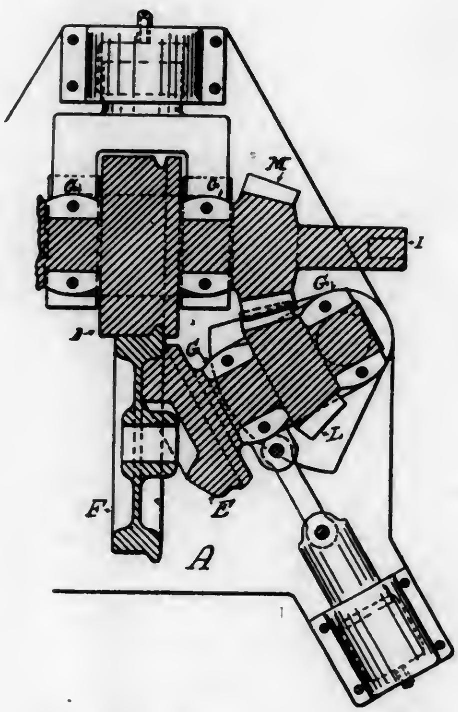


Fig. 9.

Fig. 10.

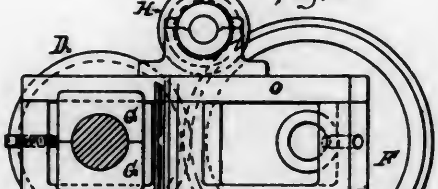


Fig. 11.

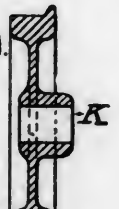


Fig. 12.

ing a web and rim of uniform section and texture, and securing in the tread of the wheel a condensed and fibrous metal of great durability and tensile strength. This, the inventors claim, is accomplished by compressing the metal of the ingot from the center toward the periphery, and by rolling down the face or tread by means of movable rolls.

In the accompanying drawings, fig. 8 is a sectional plan of the machine with a finished wheel in place between the rolls; fig. 9 is a vertical plan showing the position of the rolls; fig. 10 is a side elevation showing the bed-plate and rolls; fig. 11 shows a section of the casting of the wheel ingot before rolling, and fig. 12 shows the movable friction and steadying roll.

In these illustrations *A* is the bed-plate; *B* and *C* are the main and side housings; *D* is the tread-roll, which is made movable by means of the screws *S* or by hydraulic pressure, and has grooves on its face of the requisite form to give size and shape to the tread or flange of the wheel and also to compress and extend it to any desired diameter. *E* and *E'* are two rolls upon movable bearings, having heads of such a shape as will compress the metal of the ingot outward from the center toward the rim, and produce the desired form of the web of the wheel which is being rolled. When the requisite thickness of web is secured, these rolls continue to revolve, carrying the wheel around with them and acting as clamps supporting the metal and holding it in place until the wheel is finished by the action of the tread-roll *D*. These rolls *E* and *E'* may be given a movement in right lines, as shown in fig. 8, or may be hinged, as shown in fig. 9. *F* in fig. 8 is a view of the finished wheel between the rolls; *G G* are the roll boxes; *H* is a friction roll, adjustable so as not to interfere with the increase in the diameter of the wheel, its object being to rest upon and clasp the tread and flange and also to prevent vertical movement and consequent distortion of the wheel during the process of rolling; *I* is the shaft through which power is applied; *M* and *M'* are pinions on the shaft *I*, by which power is transmitted to the side-rolls *E* and *E'* through the gear wheels *Q* and *Q'*, so that the revolution of the tread-roll *D* upon the shaft *I* causes a corresponding operation in the side-rolls.

To operate the machine the side-rolls *E* and *E'* are drawn or swung back, thus receding from each other, being guided by the flanges of the roll-boxes *G G*, fig. 8, or by the trunnions *N N*, fig. 9, moving upon the housings *B* and *C*. These housings diverge from each other, and the withdrawing of the side rolls *E* and *E'* permits the ingot to be inserted between the rolls, which are in gear through the pinions *M* and *M'* and *Q* and *Q'*. The mill is then started, and the side-rolls *E* and *E'* are gradually forced or driven upon the web and inside of the rim of the wheel, and the tread-roll *D* is gradually forced or driven upon the rim, or tread and flange, of the wheel until the desired reduction and formation have been accomplished. These rolls operate as if that portion of the web and tread which is held firmly and revolves between them and on which they are driven were an endless bar. As this portion is reduced in thickness by the rolls as they approach one another toward a common center in the tread, it becomes elongated and is drawn outward and expanded from the hubs, thus increasing the diameter.

AIKEN'S APPARATUS FOR MAKING CAR-AXLES.

The accompanying illustrations show an improved apparatus for the manufacture of car-axles, which is covered by patent 426,653, recently issued to Henry Aiken of Pittsburgh. The method used consists, generally stated, in enclosing a suitably shaped blank or bar in dies having matrices formed therein, and then subjecting the blank to endwise or laterally applied pressure, thereby causing the metal to conform in shape to the matrices. In the accompanying drawings fig. 13 is a side elevation of the machine; fig. 14 a sectional plan on the line *x x*, fig. 13; fig. 15 is a sectional elevation on the line *y y*, figs. 13 and 14; fig. 16 is a sectional elevation on the line *z z*, fig. 15; figs. 17, 18 and 19 show the blanks and a finished axle, and fig. 20 is a transverse section of a modified arrangement of the apparatus.

The frame of the machine consists of a base, 1, cheek-pieces 2, supported by the base, and a cap, 3, resting upon the cheek-pieces, the said parts being firmly held together by the horizontal bolts 4, 5 and 6 and by the vertical bolts 7 and 8. The horizontal bolts 4 and 6 pass through the cap and base, respectively, as well as through the cheek-pieces; but the bolt 5 passes through the cheek-pieces only, and as said pieces serve as guides for the carrier-block 10 a section of pipe, 9, is placed around the bolt 5 and bears at its ends against the cheek-pieces, so as to prevent the latter from being sprung inwardly when the nuts on the ends of the bolts 5 are tightened up. The same function can be effected by forming shoulders on the bolt 5.

Between the cheek-pieces is arranged a heavy casting, forming the carrier 10, guided at its ends by the cheek-pieces, as before stated. This carrier is vertically slotted, as shown in fig. 15, so as to permit of the passage of the bolt 5 without interference with its vertical movements, which are effected by the piston 12 of the fluid-pressure cylinder 13, arranged, as

shown in figs. 13, 15 and 16 upon the base 1, and held in position laterally by a stud, 14, formed thereon and fitting in a socket in the base. The dies 15 and 16, having suitable matrices formed therein, are secured to the cap 3 and carrier 10, and in the adjacent faces of the dies, at the ends of the matrices, are cut grooves 17, which, when the dies are closed, form passages for the upsetting-plungers 18 These plungers are attached to

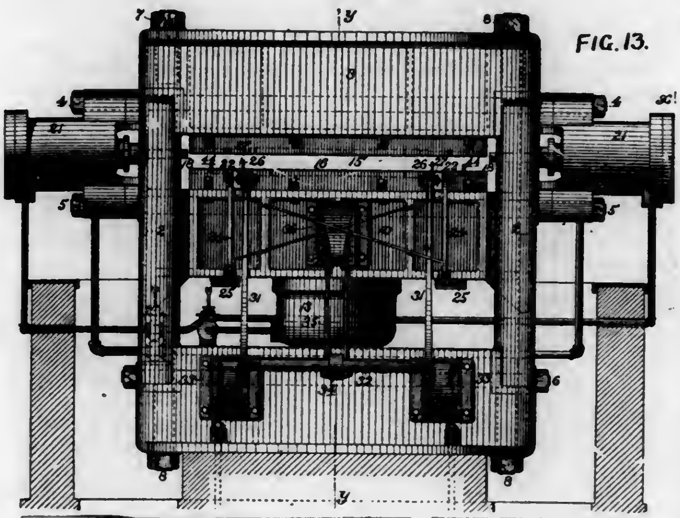


FIG. 13.

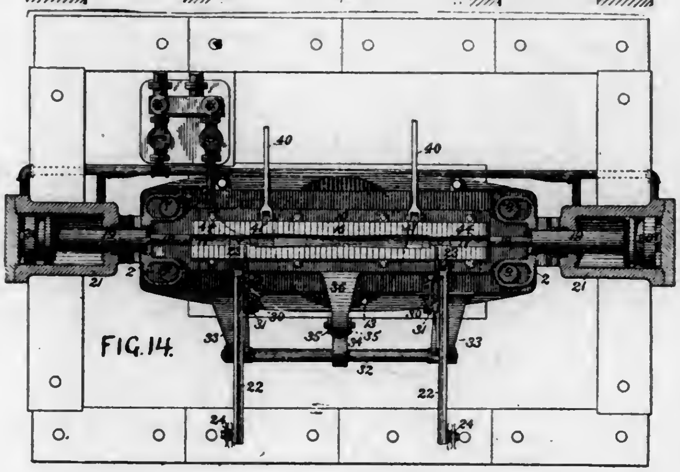


FIG. 14.

the stems 19 of the pistons 20 of the fluid-pressure cylinders 21, which are preferably secured to the cheek-pieces 2 by the bolts 4 and 5, as shown in fig. 16.

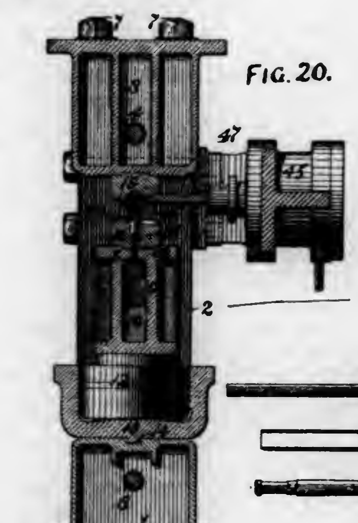


FIG. 20.

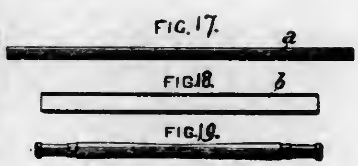


FIG. 17. FIG. 18. FIG. 19.

For convenience of operation, the machine is so arranged in a pit, as shown in figs. 13, 14 and 15, that the dies will be readily accessible from the floor-level, and when operating the blanks are placed upon rails 22, pivoted at their inner ends to ears 23 on one side of the lower movable die 16 and at their outer ends to posts 24, also pivoted to shoes 25, secured to the floor of the

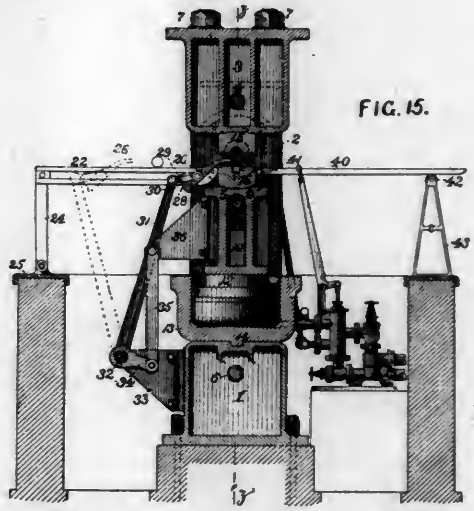


FIG. 15.

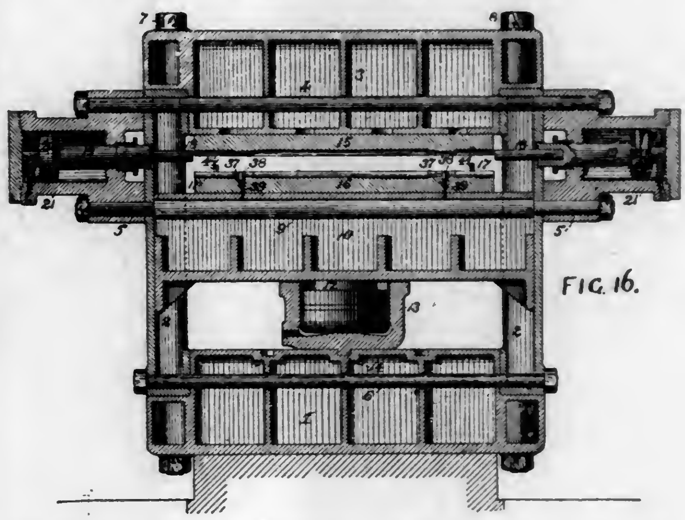


FIG. 16.

mill, as shown in figs. 14 and 15. The posts 24 are made of such a height that when the die 16 is raised the rails 22 will be level or approximately level, so that any blanks placed upon the rails may not roll off, but will either roll or slide down toward the die 16 when it is lowered, or will remain in position until forced toward and into the die by the dogs 26. These dogs are pivoted to blocks 27, mounted in dovetailed grooves in the inner walls of the rails 22, as shown in fig. 13, and have their outer ends weighted, so as to hold their inner ends normally above the rails and to permit said inner ends to be depressed and pass under a blank during the outward movement of the sliding blocks.

In order to prevent too great movement of the dogs, lugs 28 are formed on their outer ends, so as to engage pins 29 on the sliding blocks. These blocks 27 are connected by links 30 to the upper ends of the arms 31, which are attached to a rock-shaft 32, mounted in brackets 33, bolted to the base 1, as shown in figs. 13 and 15. A crank, 34, projecting from the shaft 32, is connected by a link, 35, to a bracket, 36, bolted to the carrier 10, so that when the carrier is raised the rock-shaft is so turned as to move the blocks and dogs outwardly, the latter passing under and behind the blank on the rails, and then the carrier is lowered, separating the dies, the dogs are moved inward, pushing a blank before them into the matrix of the lower die, thereby displacing a completed axle.

In the lower die are formed sockets 37 for the reception of the crutches 38, which fill the sockets and have a firm solid bearing in the bottoms thereof, and have their upper faces shaped to form a part of the matrix and register therewith during the blank-shaping operation. These crutches are provided with stems 39, extending down through the die and adapted to engage the bolt 5, or the pipe surrounding the same, when the carrier is lowered, thereby holding the crutches and the finished axle stationary while the die 16 continues its downward movement. The stems are so proportioned as to length that the axle

will be held clear of its matrix when the die has reached the lower limits of its movement, and can therefore be readily pushed from between the dies on to the receiving-rails 40 by the incoming blank. The receiving-rails 40 are pivoted at their inner ends to ears 41, formed on the side of the lower die 16, and have their outer ends supported on a friction-roller, 42, mounted in suitable bearings formed in the upper end of the standards 43, secured to the floor-plate of the mill. These standards are made of such a height that the rails 40 will be level, or approximately so, when the die 16, carrying the inner ends of the rails, is at the lower limit of its movement, but will have a downward inclination toward their outer ends when the die is raised, so that the finished axle may be automatically discharged therefrom.

In order to prevent the blanks from being pushed beyond the matrices of the dies by the dogs 26, pins 44 are placed on the discharge side of the die 16, as shown in figs. 14 and 15, and that the stop-pins may not interfere with the discharge of the finished axle, they are located beyond the ends of the matrices, so as to engage the ends of the blank, which is longer than the axle to be formed while permitting the finished axle to pass between them.

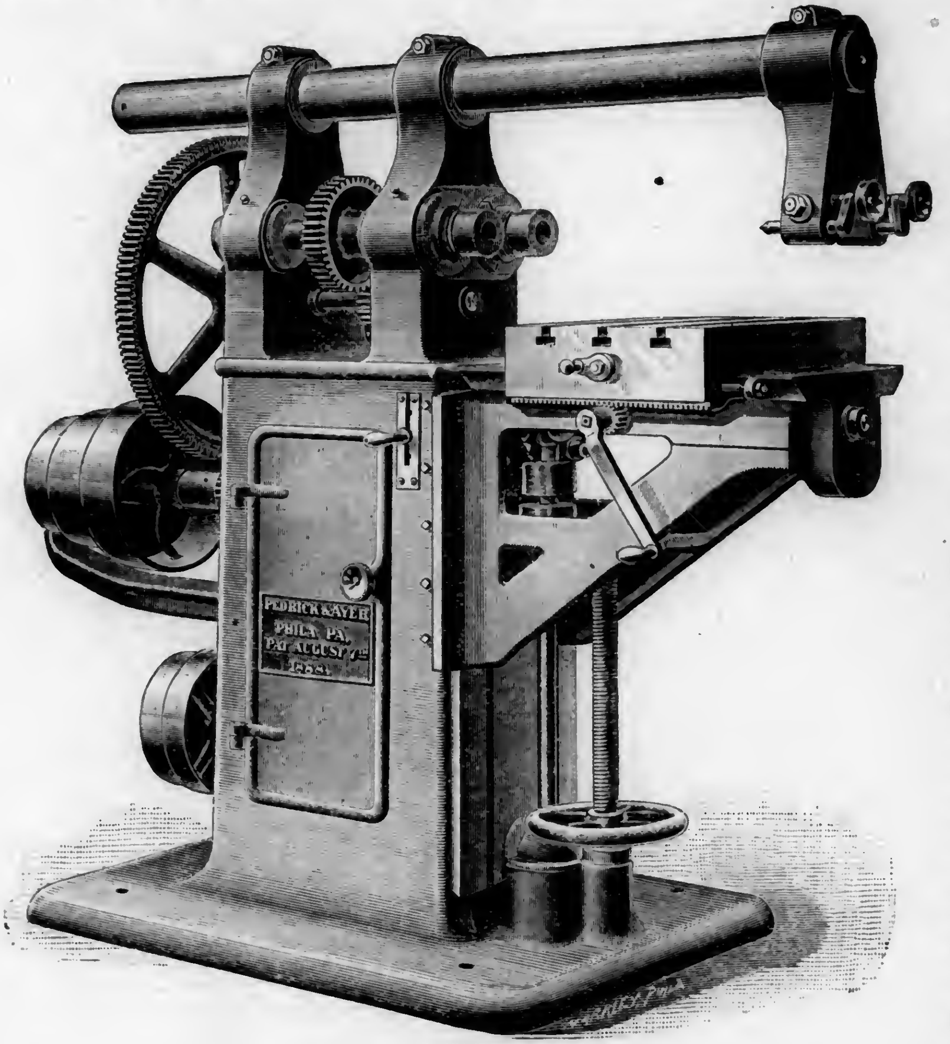
In fig. 20 is shown a form of apparatus wherein the slot through which the plunger 46 operates is formed by recesses cut in the adjacent or meeting faces of the dies 15 and 16, the plunger 46 and its operating-cylinder 45 being supported in a horizontal position by brackets 47, secured to the cap or top piece of the machine. In this construction of machine there will not be any rotation of the blank as the lower die is raised, and said die has sufficient movement to afford space when the die is at the lower limit of its movement to permit of the insertion of the blank or the removal of the finished axle under the plunger 46. As the plunger does not in this arrangement afford means for the removal of the axle, the crutches or strippers 38 are employed.

It will be observed that the blank is entirely inclosed in the die-matrix and slot leading therefrom before any flow of the metal occurs, and also that the operative face of the plunger 46 is so constructed that its edges are merged into the walls of the die-matrix, and that therefore there will not be any liability of forming a fin or other projection on the axle. The meeting faces of the dies being held in close contact, no metal can be forced between them, and the plunger fitting snugly in the slot in the die 16, and the edges of its operative faces being made like a knife and merging its walls into the wall of the matrix, no projection or excrescence can be formed on the axle.

It will be observed that the plunger 46 operates as regards the lifting of the finished axle from the matrix of the die 16 exactly the same as the crutches 38, the movement of the plunger being arrested by its lower end coming in contact with the cylinders 13, while the carrier and die 16 continue their downward movement.

Manufactures.

A New Duplex Boring Machine.



DUPLEX BORING MACHINE.

THE accompanying illustration shows a duplex boring machine which was designed and built for the purpose of boring out two pump cylinders, but which can be used for boring two parallel cylinders of any kind. The distance between the centers of boring bars is fixed for each machine, but in the building of the tool it can be made any distance required. The platen is fed by a nut and screw, the latter being driven by a $2\frac{1}{2}$-in. belt. The power-feed can be run either way without any change in belting, the gearing being reversed by means of a handle shown near the upper right-hand corner of the door in the base of the machine. The feed-nut can be turned in or out of contact with the screw by one turn of a small crank. The hand-feed of the platen has a quick return for counter-boring, and the total travel of the table is 14 in. The knee or bracket which supports the platen can be raised and lowered, and is securely bolted to the column by bolts whose heads fit in T-slots. The spindles of the machine are made of steel, and each has a main journal $3\frac{1}{2} \times 6$ in. and a rear journal $2\frac{9}{16} \times 5$ in. A hole $1\frac{1}{16}$ in. in diameter runs through each spindle, and the ends are bored taper to receive cutter bars or other tools, the hole for the same being 2 in. in diameter at the large end, $1\frac{1}{2}$ in. at the small end and 12 in. deep. Along the top of the machine there is a $4\frac{1}{2}$-in. bar of hammered steel which holds the center supports for the ends of the boring bars, when such support is needed. The platen is 16 in. wide and 20 in. long. The machine is driven by a three-step cone, the largest diameter of which is 14 in.; the face of each step is $4\frac{1}{8}$ in. The machine is back-geared four to one, thus giving ample power.

The total weight of the machine shown in the cut is 4,500 lbs. It is a good example of the special tools so extensively and profitably used in modern machine-shop practice. It was built by the well-known firm of Pedrick & Ayer, of Philadelphia.

Locomotives.

THE Baldwin Locomotive Works, Philadelphia, are at present at work on orders for 32 locomotives for the Union Pacific; 30 for the Manhattan Elevated in New York; 27 for the Northern Pacific; 48 for the Denver & Rio Grande; 12 for the Chicago, Rock Island & Pacific, and 20 for the Baltimore & Ohio. Three of those for the last-named road are heavy passenger engines with cylinders 20×24 in., and driving-wheels 6 ft. 6 in. in diameter. Recent orders include 10 heavy engines for the Mexican Central; 12 for the Mexican Interoceanic and 12 for the Mexican Pacific. Three compound locomotives are

nearly completed for a railroad in Brazil, and one compound consolidation freight for the Mexican National. Other foreign orders include eight engines for Japan and three for the railroad from Jaffa to Jerusalem.

THE Pittsburgh Locomotive Works have recently built seven locomotives for the Louisville, New Albany & Chicago Railroad.

THE Baldwin Locomotive Works are building for the Baltimore & Ohio three passenger engines with 20 X 24-in. cylinders and 78-in. drivers; also seven heavy ten-wheel engines with 21 X 24-in. cylinders.

The New Model Lake Steamer.

THE accompanying illustration—for which we are indebted to the Cleveland *Marine Review*—shows the steamer *Colgate Hoyt*, the first steamboat built by the American Barge Company, of West Superior, Wis., after the model for whale-shaped freight carriers devised by Captain Alexander McDougal. A number of these barges have already been built, and the intention is to have the steamboat tow a train of five or six of the loaded barges, bringing transportation expenses down to the lowest possible point. The Company has established large yards at West Superior for the construction of these vessels, which are, as the illustration shows, really *whale-shaped*, and which, the inventor claims, present the largest space for cargo combined with a form adapted to resist storms and other obstacles to navigation, and to present the least resistance to propulsion.

The steamer is necessarily arranged somewhat differently from the barges, the principal changes being in the house arrangements above the deck. The hull is the same as that of the barges excepting in the run aft, which is more like an ordinary steamer. The vessel shown in the illustration will carry about 2,600 net tons on 15 ft. of water, and with this draft the cabin deck will be 15 ft. above water. The general dimensions are: 280 ft. long over all, 30 ft. beam and 22 ft. moulded depth. She has Hodge fore-and-aft compound engines, with cylinders 26 and 50 in. in diameter by 42 in stroke. The boilers, built by the Lake Erie Boiler Works, at Buffalo, N. Y., are $11\frac{1}{2}$ ft. long, and carry 150 lbs to the square inch. The quarters for officers and crew are better than might be expected from the peculiar arrangement of the ship.

The cabin rests on three turrets, supported on the sides by 12 ventilation pipes. Four of these ventilate the engine-room, four perform the same duty for the fire-hold, and four the cargo hold. The captain and other officers will all have spacious quarters in the cabin above deck, which also contains a dining-room 20 X 11 ft. The different rooms are finished in oak and elegantly furnished. The wheelmen, firemen and other members of the crew have quarters below deck, forward and aft, and the engine-room is large and well lighted. In the turret forward is one of the American Ship Windlass Company's steam windlasses, with the capstan above. The *Hoyt* has hand-steering gear, with the shaft and hub of the steering wheel of brass to avoid affecting the compass. On the port side of the cabin forward, just aft of the pilot-house, there is also a chart room and office combined.

It is further claimed for these vessels that they can be built for 25 per cent. less than a wooden steamer of the same carrying capacity. This is a very important consideration, especially where the traffic is carried on under so sharp a competition as on the lakes.

On her first voyage down the *Colgate Hoyt* carried a cargo of 2,800 tons of iron ore, her draft with this great load being only 15 ft. The average speed on this trip, from Ashland to the Sault Ste. Marie, was 13 miles an hour.

STEAMER "COLGATE HOYT."

Manufacturing Notes.

THE shops of William Sellers & Company, Philadelphia, are now building for the Baldwin Locomotive Works' new shops, two 100-ton high-speed traveling cranes, each with two 50-ton trolleys, for a span of about 75 ft., and for a shop about 340 ft. long. Each crane is to be driven by electric motors on the hanging platform, and is to have the following speed per minute: 100 ft. and 200 ft. on runway, 50 ft. and 100 ft. on bridge, and 5, 10, 20 and 40 ft. hoisting and lowering, all variable without shock or jar from zero to maximum, at the will of the operator.

THE Pond Engineering Company, of St. Louis, has recently opened branch offices in Dallas, Tex., and Seattle, Wash., to assist in handling its increasing business in the Southwest and on the Pacific Coast.

Cars.

THE Central Railroad of Georgia has recently placed an order with the Ohio Falls Car Company, Jeffersonville, Ind., for 32 passenger and two sleeping cars; also for 100 coal and 50 stock cars.

THE North Carolina Car Company, Raleigh, N. C., is building a number of freight cars for the Seaboard & Roanoke Railroad.

THE United States Rolling Stock Company's Shops in Anniston, Ala., are building cars for the East Tennessee, Virginia & Georgia; the Georgia Southern & Florida, and the Savannah, Americus & Montgomery Roads

NEW car shops of considerable size are being built at Basic City, Va.

THE Baltimore & Ohio Railroad Company has let contracts to the Pullman shops, Pullman, Ill., for 1,000 gondola cars 34 ft. long; to the Wells & French Company, Chicago, for 250

flat cars; also for 500 box cars, to be 34 ft. long, 50,000 lbs. capacity, to have journals $4\frac{1}{4} \times 8$ in., and to be fitted with Westinghouse air-brakes and automatic couplers.

THE Edgar Thomson Steel Works, Braddock, Pa., are to be enlarged by the addition of three 15-ton converters.

THE Standard Metal Tie & Construction Company, New York, has just finished laying 1,500 of its ties on the Delaware & Hudson Canal Company's line near Ballston, N. Y.

THE Ross-Meehan Brake-Shoe Foundry Company is about to build a foundry and a malleable iron plant at Chattanooga, Tenn.

NOTICE is given by the Lappin Brake Shoe Company, of New York, that the recent enlargement of its works has given increased facilities and lessened the cost of manufacture, and the price of both plain and flanged shoes has therefore been reduced to 4 cents per lb.

Bridges.

THE Pottsville Bridge Company has recently been organized to carry on a bridge building business in connection with the works of the Pottsville Iron & Steel Company, at Pottsville, Pa. The main office will be in Philadelphia. The officers are: President, William Atkins; Vice-President and Engineer, H. L. Forte; Treasurer, John M. Callen.

THE San Francisco Bridge Company, San Francisco, Cal., has the contract for building railroad bridges on the Northern Pacific Road over the Snohomish, Skagit and Stillaquamish rivers in Washington.

THE contract for a steel bridge over the Savannah River near Savannah, Ga., has been let to Mr. Grant Wilkins of Atlanta, Ga., who takes the entire contract, both for the foundations, masonry and superstructure. The bridge will have two fixed spans of 125 ft. each, and one draw span of 250 ft.

THE Detroit Bridge & Iron Company is building an iron draw-span on the Fairhaven & Southern Railroad.

THE Youngstown Bridge Company, Youngstown, O., has the contract for a bridge over Klingle Creek near Washington. The same company is building several highway bridges in West Virginia.

THE Edge Moor Bridge Company, Edge Moor, Del., has the contract for a bridge over Rock Creek near Washington.

THE channel span of the Ohio River Connecting Bridge, near Pittsburgh, was successfully placed August 19. This span, which is entirely of steel, is 523 ft. long, and the trusses are 73 ft. in depth; it was erected on barges and floated into place when the water was at the proper stage. When it was in place the barges were sunk gradually, leaving the span resting on the piers. The placing required very careful work, and was completed without accident.

Marine Engineering.

IN the yard of the Detroit Dry Dock Company at Wyandotte, Mich., there was recently launched the steel propeller *Maryland*, which is intended to carry iron ore from Escanaba to Chicago. The *Maryland* is 335 ft. over all; 316 ft. on the keel; 42 ft. beam, and 24 ft. depth of hold. She is expected to carry 3,500 tons on a draft of 16 ft. She has a double bottom, and can carry 1,200 tons of water ballast. The engines are triple-expansion, with cylinders 22, 35 and 56 in. in diameter and 44 in. stroke. Steam is furnished by two steel boilers, each 14 ft. 2 in. in diameter and 11 ft. 6 in. long, built to carry 160 lbs. working pressure.

Two steel steamers intended for coasting trade are nearly ready to launch from the Wheeler Yards at Bay City, Mich. These vessels are 300 ft. long, 41 ft. beam, and are intended to carry 3,500 tons on 22 ft. draft. The engines are of the triple-expansion, surface-condensing type, with cylinders 21, 35 and 56 in. in diameter and 42 in. stroke. The building of coasting steamers at a Lake yard is something new.

THE new steam ferry-boat *G. R. Sherman*, built for the ferry across Lake Champlain between Port Henry, N. Y., and Chimney Point, Vt., is 99 ft. long. It is a side-wheel boat, the paddles being driven by a compound condensing engine with cylinders 10 in. and $17\frac{3}{4}$ in. in diameter and 12 in. stroke. There are two boilers, each 4 ft. 8 in. in diameter and 8 ft. long, carrying a working pressure of 125 lbs. The engine and boilers were built by the Erie Iron Works, Erie, Pa. The ferry is $2\frac{1}{4}$ miles long, and the usual speed is 8 miles an hour.

THE steamship *Essex*, for the Merchants' & Miners' Transportation Company, of Boston, was recently launched from the Cramp Yards in Philadelphia. The *Essex* is 260 ft. long, 40 ft. beam and 35 ft. 6 in. depth of hold. She has a triple-expansion engine with cylinders 24, 39 and 59 in. by 48 in. stroke. The working pressure is 155 lbs. The ship is expected to make from 14 to 15 knots an hour.

OBITUARY.

SAMUEL A. BLACK, who died at his home in Bryn Mawr, Pa., August 2, aged 70 years, was for many years connected with the Pennsylvania Railroad, having served in different positions, and from 1858 to 1874 as Division Superintendent. He was afterward for some years Superintendent of the Northern Pacific, but retired from railroad work some 10 years ago.

M. K. BELKNAP, who died suddenly in Louisville, Ky., July 19, was a civil engineer, and studied his profession in France. He served on the Louisville & Nashville some 10 years, and in 1879 was appointed Engineer and Superintendent of the Mexican Central. A year later he returned to the United States, and in 1885 was made Superintendent of the Vicksburg & Meridian and the Vicksburg, Shreveport & Pacific Railroad. In 1887 he was appointed General Superintendent of the Central Railroad of Georgia, and later General Manager. He resigned that office last year to accept the Presidency of a banking company in the City of Mexico.

JOHN BRANDT, who died in Portland, Ore., recently, aged 65 years, was born in Lancaster, Pa., and began work on the Erie Railroad, where he served as engineer and afterward as Master Mechanic in charge of the Susquehanna shops. He was afterward for a time connected with the old New Jersey Locomotive & Machine Works, in Paterson, and was Superintendent of the Cincinnati & Chicago Air Line Railroad. In 1872 he was appointed Master Mechanic of the Oregon & California Railroad. For some years he had been Superintendent of the Southern Pacific Lines in Oregon.

HENRY J. DAVISON died on board the steamship *Majestic*, at Liverpool, July 22, aged 55 years. He was born in New York, and at an early age entered the old Chelsea Iron Works, and after learning the trade became a contractor on his own account. He obtained considerable reputation by undertaking the removal of the remains of the Crystal Palace after the building had been destroyed by fire, which was considered a very difficult undertaking. He established himself finally as a mechanical and consulting engineer in New York, and was employed in many important works. He built gas works in a number of cities, and was very successful in introducing the manufacture of water gas. He constructed the telegraph lines in the United States of Colombia, and was instrumental in introducing light draft steamers on the Magdalena River in that country. He was also one of the projectors of the elevated railroad system in Brooklyn, and was largely instrumental in securing its construction. Mr. Davison was a member of several public bodies, and was well-known for his public spirit and interest in the general welfare. At the time of his death he had just taken passage on the *Majestic* on his return from a trip in Europe.

PERSONALS.

W. A. CATTELL, heretofore Assistant Superintendent of Roadway of the Long Island Railroad, is now Assistant Chief Engineer of that road.

C. B. COUCH has resigned his office as Superintendent of the Eastern Division of the Lake Shore & Michigan Southern, on account of ill health.

A. L. GARDNER is Manager of the Baltimore & Washington Car Service Association, which includes all the railroad lines entering or passing through Baltimore.

I. GROVE has been appointed General Manager of the Colorado Coal & Iron Company, with office at Pueblo, Col. He was recently in charge of iron works at Youngstown, O.

P. D. FORD, heretofore Superintendent of Roadway of the

Long Island Railroad, is now Chief Engineer of the road, in charge of bridges and tracks, as well as of all surveys and construction.

E. M. HERR has been appointed Master Mechanic of the Chicago, Milwaukee & St. Paul Railroad at Milwaukee, Wis. He was recently Division Superintendent on the Chicago, Burlington & Quincy.

H. H. FILLEY, Consulting Engineer of the Mexican National Construction Company, who has been residing in Kansas City for some time past, has returned to Mexico. His residence will be in the City of Mexico.

JOHN ORTTON has been appointed Superintendent of Motive Power of the Toledo, St. Louis & Kansas City Railroad. Mr. Ortton has had an extensive experience both in England and in this country, where he has served on the Great Western, the New York Central & Hudson River and other prominent lines.

RICHARD COUGHLIN, of Paterson, N. J., who is now 80 years of age, claims the honor of being the oldest railroad conductor in the United States, as he had charge of a train on the old Paterson & Hudson River Railroad—now part of the Erie—in 1833. Mr. Coughlin is still well and strong, though he has retired from active business.

R. C. CARPENTER, for 15 years past Professor of Engineering in the Michigan Agricultural College, has been appointed Professor of Experimental Mechanics at Cornell University, and has removed to Ithaca, N. Y. Professor Carpenter has been an active member of the Michigan Engineering Society, was for several years its Secretary and is now the President.

PROCEEDINGS OF SOCIETIES.

Engineers' Society of Western Pennsylvania.—At the regular meeting in Pittsburgh, June 17, resolutions were adopted urging upon the Government the erection of a movable dam in place of the fixed dam and lock which it is proposed to put up at Herr's Island in the Allegheny River, for the reason that a fixed dam will, during ordinary floods, raise the surface of the water several feet, causing much loss and damage to manufacturing interests, and also preventing the free passage of ice.

Mr. Phineas Barnes made an address on Sundry Rolling Mill Appliances, illustrating his remarks upon a blackboard.

Master Car Builders' Association.—Secretary John W. Cloud has issued a circular, accompanied by very full illustrations, submitting to members of the Association for their decision by letter-ballot the several standards proposed at the recent Convention. The questions are as follows:

1. On the adoption as a standard of the journal box, bearings with wedge, and the malleable lid for cars of 60,000 lbs. capacity, as shown by the drawings.
2. On the adoption as a standard of the same form and size of malleable lid for the standard journal-box for cars of 40,000 lbs. capacity. The drawings for this journal-box are so made that a pressed steel lid may be used instead of the malleable lid.
3. The adoption as a standard of the plans presented at the Convention for loading logs and poles upon cars, the method being shown in the drawings accompanying the circular.
4. On the adoption as a standard for the plans for racking cars for loading bark, this plan being also shown in the drawings.
5. On the adoption as the standard height for draw-bars on passenger equipment cars of 35 in. from top of rail to center of draw-bar, when the car is light.
6. On the adoption as a standard for safety chains for passenger equipment cars, a chain with all links made of $\frac{7}{8}$-in. iron and $1\frac{1}{2}$ in. wide inside; to be arranged as proposed at the Convention and shown on the drawings.
7. On the adoption as a standard of 40° as the lateral angle which the brake beam lever makes with the vertical.
8. On the adoption as a standard of a fitting on the ends of train-pipe for steam heating, consisting of a 2-in. female pipe fitted with standard pipe-thread.

Civil Engineers' Club of Cleveland.—At the regular meeting, Cleveland, O., August 12, a committee of three was appointed to co-operate with the committee of the Western Society of Engineers in forming a plan for holding an International Congress of engineers in Chicago in connection with the World's Fair in that city.

A paper by Mr. James Ritchie on some Recent Constructions in Railroad Bridges was read.

The Author began by noting the increased activity in the construction of iron railroad bridges in the Southern States, showing that the desire for more permanent and substantial work was taking more hold of the managers of the Southern roads. The largest recent bridge of note is that across the Ohio River, at Ceredo, W. Va., consisting of one channel span of 518 ft., two side spans 298 ft. each, and a series of approach spans, the total weighing upward of 3,250 tons. A large number of other bridges are in process of construction, including many plate girders, and fixed and draw spans up to 212 ft. In the Southwest, considerable iron bridge construction is going on, and in the Northwest there is an increasing number of these iron bridges; also in the Northeast many bridges are building. The Maine Central is replacing its wooden bridges by iron ones, while the New York Central is building several bridges of steel. Particular mention is made of a plate girder span of the New York Central, 115 ft. in length and 9 ft. deep, in which the web plates are placed with the fiber vertical. The new swing bridge on the Lake Shore Road, across the Cuyahoga River, is described as a double-track through bridge 306 ft. long, with steel eye-bars, and the balance of iron. The total weight of the superstructure is 328 tons; the turn-table 133 tons. In commenting upon specifications of bridges, he regards those by Mr. George S. Morrison, for the Memphis Bridge, as the most complete and systematic, and on account of the minuteness of their details, they are not susceptible of being evaded. Nothing impossible to comply with should be written in specifications, and all reasonable conditions should be rigidly enforced. The use of steel in bridges, seems to be increasing, and many roads allow Bessemer or open-hearth to be used, while the New York Central allows the use of open-hearth only. In testing full-sized iron eye-bars to destruction, the writer has noticed that failure takes place near one head or the other, indication that the material might have been injured in manufacturing, and recommends annealing the same, as is done with steel bars. This might not produce the desired result, but a few experiments in this manner might be of great benefit.

The reading of this paper was followed by a general discussion which covered the use of iron and steel in bridge construction, the different kinds of steel, the length of plate girders and lattice bridges, and the relative merits of pin-connected and riveted bridges.

Iron and Steel Institute.—The provisional list of the papers to be read at the meeting of the British Iron & Steel Institute in this country, in October, has been issued by the Secretary. It will be seen that all the papers announced are by Americans.

1. American Blast Furnace Yields; James Gayley, Pittsburgh.
2. Testing Materials of Construction in the United States; Messrs. Hunt & Clapp, Pittsburgh.
3. The Manufacture of Steel in the United States; Henry M. Howe, Boston.
4. The Thomson Electric Welding Process; Professor Thomson, New York.
5. The Manufacture of Spirally Welded Steel Pipes in the United States; J. C. Bayles, New York.
6. The Development of the Iron Manufacture of Virginia; E. C. Pechin, Cleveland, O.
7. The Use of Water Gas in the United States; B. Loomis, Hartford, Conn.
8. The Coke Industry of the United States; J. D. Weeks, Pittsburgh.
9. Recent Progress in the Manufacture of War Material in the United States; W. H. Jaques, Bethlehem, Pa.
10. Composition and Wearing Qualities of Steel Rails; Dr. Charles B. Dudley, Altoona, Pa.

Two papers by members of the Institute will be read at the International Meeting in Pittsburgh as follows:

1. Protection of Iron and Steel Ships against Foundering from Injury to their Shells; Sir N. Barnaby, London.
2. Recent Development of Marine Engineering; A. E. Seaton Hull, England.

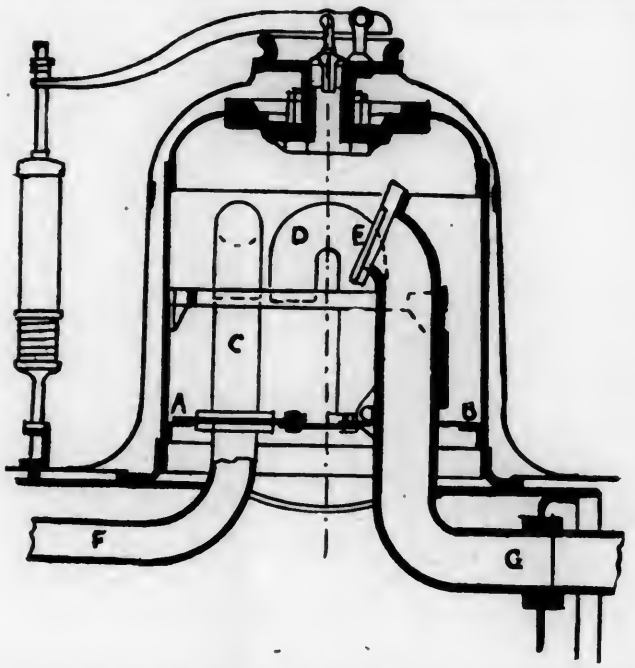
Sir Lowthian Bell has also promised to prepare a paper setting forth his views on the present state of the iron manufacture.

NOTES AND NEWS.

Ice Making in New York.—The scarcity of stored ice naturally resulting from a very hot summer following a mild winter has stimulated the artificial manufacture of ice, and it is to be tried on a large scale in New York. The New York Steam Company has nearly completed three factories for that purpose. The first one occupies a building 25 × 100 ft. in size and five stories high, which will have a daily capacity of 60 tons of ice, besides cooling two floors of the building which are used

for storage. The other two factories are each 100 × 100 ft. in size, with a capacity for making 120 tons of ice daily. In all these the ammonia compression system is used, and the Company has very little doubt that they will prove a financial success.

A Locomotive Steam Dome.—The accompanying sketch shows an arrangement adopted on the Paris, Lyons & Mediterranean Railroad for locomotive boilers, the object being to secure dry steam. The upper part of the dome is separated from



the boiler by the diaphragm *A B*; steam is admitted by two curved pipes *C* and *D*, the lower end of *D* opening directly into the boiler, while *C* is connected with the dry pipe *F*, which runs back to the rear end of the boiler. The throttle valve, of the gridiron pattern, is at *E*, steam passing into the steam-pipe *G* as shown.

Steam entering the dome through the pipes *C* and *D* is, by their curved form, thrown down against the diaphragm *A B*, where any particles of water which may be carried over will be deposited. It is stated that this arrangement works very well in practice, giving dry steam almost invariably, under all conditions of working.

International Electrical Exhibition.—An International Electrical Exhibition is going to take place in Frankfurt-am-Main, in Germany, in 1891, at which electrical apparatus of all descriptions will be shown. Special attention will be paid to exhibits and statements of the progress made in electric lighting and the use of electricity in supplying power in cities.

In connection with this Exhibition, it is intended to hold a congress of electrical engineers, to which delegates from all countries will be invited. In connection with this an invitation is to be extended to the members of the International Gas Congress, which meets at Munich, to attend, in order that, in Germany at least, matters may be so arranged as to avoid unnecessary rivalry between the electric lighting and gas interests in the cities.

Improvement of the Navigation of the Danube.—After long negotiation, arrangements have been finally completed, and a plan has been agreed upon for the impovement of the navigation of the Lower Danube, a matter of great importance to the countries and cities of Eastern Europe. The works required are of three kinds:

1. The deepening of the river channel through the rocky bars which at present obstruct it.
2. The construction of dams to secure uniform depth of water at all seasons.
3. The excavation of the navigable canal around the famous Iron Gates.

The work of the first class includes the blasting out of the reefs in the bed of the river at Stenka, at Kozla, at Doghe, at Izlas, at Jucz and at Greben. The depth of the excavation varies at these points, but at all of them it is proposed to make a channel not less than 2 m. (6.56 ft.) in depth at mean low water, and 60 m. (197 ft.) in width. These works will require a total amount of excavation of about 210,000 cub. yds., a considerable portion of which will be rock.

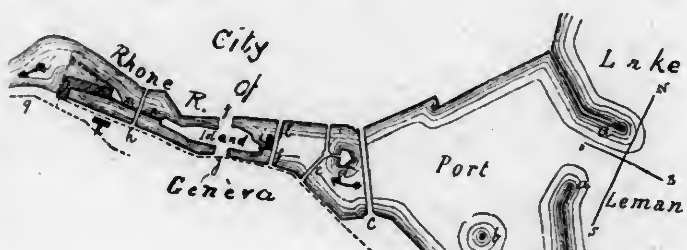
The second part of the work will require the construction of two dams. The first will be situated at the reef known as the Greben Spit, at the foot of the Greben Rapids, the object being to establish a level of water over the rapids. The dam here will be a large one, nearly 20,000 ft. in length and 10 ft. wide at the summit, the sides having an inclination of 1 to 1½. It will be a rock-filled dam and will be about 7 ft. in height above the present average level of the river. The second dam will be situated near the town of Jucz and will be somewhat shorter, being 12,600 ft. in length. The boats will pass these dams by means of locks.

At the famous Iron Gates, which have so long been a barrier to the navigation of the river, a canal will be built, the engineers considering that this will be the most direct and cheapest method of overcoming the obstruction. This canal will follow the right bank of the stream; will be 260 ft. wide at the surface and 7 ft. in depth; will be 6,955 ft. in length, and to a considerable distance will be close to the river and separated from it only by a dike. This canal will require the excavation of about 330,000 cub. yds. of rock.

It is estimated that all the works can be completed by the close of 1895, and that their total cost will be $5,000,000.

River Improvements at Geneva.—An interesting work has lately been completed at Geneva in Switzerland, the objects of which were two: To utilize the power developed by the Rhone on its exit from Lake Leman or Geneva, and to regulate also the level of the lake as far as possible. Some works formerly constructed by the city of Geneva had so far obstructed the course of the river as to raise the level of the lake at the time of the melting of the mountain snows and cause an overflow of its banks, which had resulted in a dispute between the cantons of Geneva and Vaud, which has been settled by the new arrangement.

The works included the clearing out and deepening of the river bed; the construction of a power-house containing a number of turbines, and the dividing of the channel into two parts, one of which remains unobstructed at all seasons, while the other, by means of an island and a dike extending from the island to the power-house, is directed to the latter, where its waters are employed to drive the turbine wheels. Gates are provided in the dike by means of which in time of flood the amount of water passing down the river can be increased and the level of the lake kept even, within comparatively narrow limits. The power developed by the turbine wheels is used to pump water from the river to a reservoir situated upon a hill at a considerable height above the city, and from this reservoir the water supply of the town is drawn. It is also used for another purpose, for the power was found to be sufficient to pump out more water than was required for ordinary domestic purposes, and in addition it is now supplied to a number of manufacturing establishments of different capacities, where it is used to furnish power. Arrangements are also being made for building a second reservoir, from which water can be supplied at higher pressure, fur-



nishing a greater amount of power, and in time it is thought that most of the factories in the city will be run in this way. At present 10 turbine wheels are in use in the power-house, and this number can be doubled without exhausting the supply of water from the river which can be utilized.

At the close of the last year these city works furnished a total amount of 1,440 H. P. to 201 different motors, including those employed in the Central Electric Lighting Station, and in 80 different factories. When the high-pressure system is completed this force will be largely increased.

The accompanying engraving gives a general idea of the arrangement of the works. It is a sketch map showing their position, in which *a a* is the entrance into the port of Geneva from the lake; *c*, *e*, *f*, *g* and *h* are bridges over the river; *i* is the old power-house and dam, now removed; *o* is the new power-house, and *m n* the dike below the island above referred to, in which gates can be opened when necessary to carry off the water.

Electric Case-Hardening.—Professor Elihu Thomson has recently devised a method of case-hardening iron or steel by means of the heat produced by the passage of an electric current. His process consists essentially in heating the object electrically, and then applying to the metal so heated a surrounding envelope (either gaseous, fluid or solid), for the purpose of changing or preventing change in the quality of the material, according to the special end to be attained.

The method is applicable not only to those cases where it is desirable to prevent oxidation or change of character in the sur-

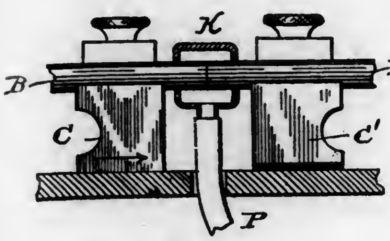


Fig. 1.

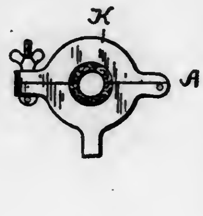


Fig. 2.

face of the metal object which is heated in the welding, forging, or shaping operation, but is also applicable to producing an addition to, or modification in, the character of the surfaces of the metal object, either independently of, or simultaneously with, the forging, shaping or other working operation performed upon the metal. Thus, for instance, it can be applied to the local hardening of parts of steel bars and the local case hardening of iron or mild steel bars when heated by the passage of the current for the purpose of welding, forging, shaping, etc.

To prevent oxidation Professor Thomson surrounds the iron and steel bars with a hydrocarbon gas or other gas containing no oxygen, such as hydrogen or nitrogen. To chill and harden steel the heated bars are suddenly surrounded with cooling fluid, such as water or oil. To case-harden the bar it is surrounded with a layer of case-hardening flux—such as cyanide of potassium, yellow prussiate of potash, shavings of horn, animal charcoal, leather cuttings, and carbonate of potash, or the like—and the pieces kept hot by the current until the required case-hardening is effected as a result of the addition of carbon to the surface layer of the material.

The accompanying illustration, fig. 1, shows the apparatus designed to accomplish this. As shown, the bar to be treated is surrounded by a casing, *K*. This casing is supplied, through a pipe, *P*, with ordinary coal-gas or gasoline vapor during the heating of the metal, so as to preserve the same from oxidation during the welding or like operation performed upon the object heated.

The casing is constructed of sheet-iron, and made in two parts, hinged at *A*, as shown in fig. 2. Evidently it must not make electrical contact with the object treated, but must be guarded therefrom by mica, asbestos or other insulating and refractory material applied at the points where the object enters the casing.

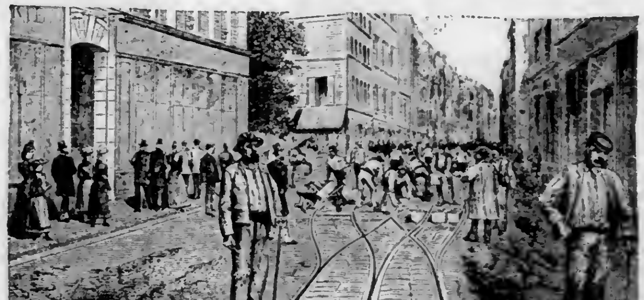
Oxidizable metals are by this means thoroughly protected at their surface, and, in fact, with gases rich in carbon, will receive when highly heated a veritable protective layer of deposited carbon, which gradually carbonizes the surface of an iron bar while heated and steelifies or case-hardens it.—*Electrical Engineer.*

A Long Electric Railroad.—The longest electric railroad yet proposed is a line from St. Petersburg, Russia, northeast to Archangel on the White Sea, a distance of 500 miles. It is proposed to furnish power from a series of generating stations placed at convenient points along the line, and the total cost, including equipment, is estimated at only about $15,000 per mile.

Archangel, which is a port having a considerable commerce at certain seasons of the year, lies in 64½° north latitude, close to the Arctic Circle, and it is claimed by the advocates of the lines that the electric road will overcome the difficulty which might be experienced in running steam locomotives in winter in that extreme northern latitude.

Petroleum in India.—In a lecture recently delivered before the London Society of Chemical Industry, Mr. Boverton Redwood stated that in India petroleum occurs in Upper and Lower Burma (including the Arakan Islands), in Assam, in the Punjab, and in Beloochistan, and described in detail the various deposits, as well as the steps which have been taken to render them commercially available. In Arakan the most productive fields were believed to be those of Ramri and the eastern Baranga Island, in both of which localities petroleum of a very high quality, in some cases sufficiently pure to be capable of being burned in ordinary lamps in its crude state, was obtained. The well-known oil fields of Upper Burma situated near Yenangyoung, the product of which has long been an article of commerce, were next described. In his account of the Punjab oil deposits attention was directed to the importance of the results, especially from the point of view of providing liquid fuel for use on the railways, which had attended the drilling operations at Khatan, in Beloochistan. The lecture was illustrated by a large number of typical samples of crude petroleum from the various districts enumerated, and full particulars were given of the physical and chemical characteristics of these samples. In India, as in Russia and Galicia, owing to the disturbed character of the strata in which petroleum is found, drilling is attended with difficulties. The most abundant supplies of oil were those obtained from the wells at Khatan, any one of the five wells already drilled being capable of furnishing the entire supply of 50,000 barrels of oil a year, which is estimated to be the amount required for the Sind-Pishin section of the Northwestern Railway. From the point of view of the kerosene manufacturer the Arakan oil was the best, but, on the other hand, much of the Yenangyoung oil yielded a large percentage of paraffin, which was a valuable product; and the yield of kerosene from the latter oil was capable of being largely increased by the adoption of a process recently devised by Professor Dewar and the lecturer. Too little was at present known about the oil fields of India to admit of a confident prediction as to their future. But it was pointed out that unless the necessary operations were carried out under skilful, energetic, and experienced management, disappointment and discouragement would probably ensue, and the development of the oil fields of India would be retarded. The action of the Indian Government in proposing to sell the oil-producing territories in sections, instead of granting prospecting licenses, was commended as being likely to afford some guarantee for efficient development. In the discussion which followed the lecture, Mr. Charles Marvin gave a number of interesting particulars in reference to the immense importance of the liquid fuel question, in relation to the action which Russia had been enabled to take in supplying her railroads with petroleum refuse from Baku.

Cable Railroad in Paris.—Paris is soon to have its first cable railroad, which will connect the Belleville and Montmartre districts. The cable-driving machinery and the grips used will

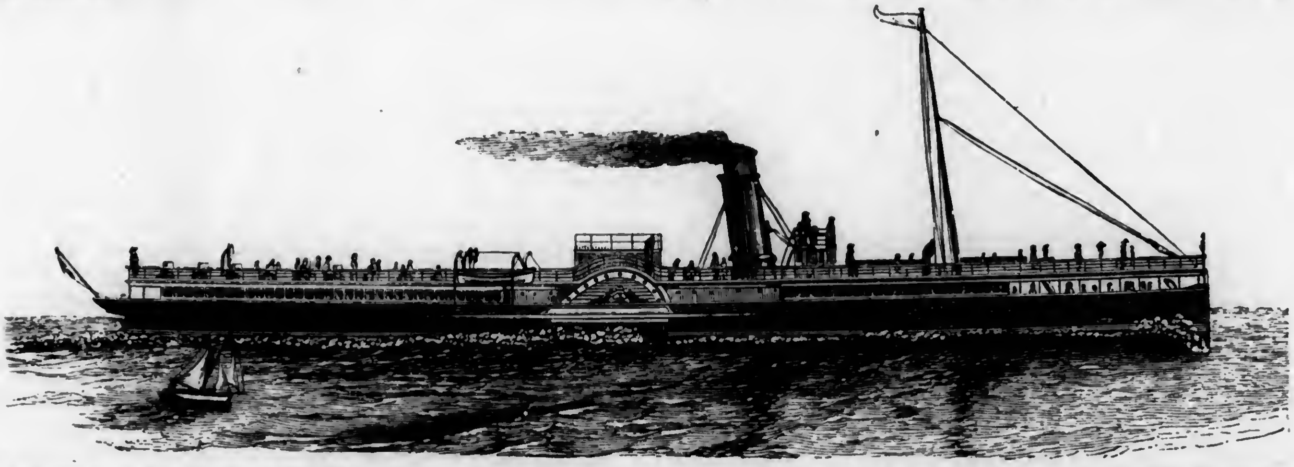


be copied from American patterns. The cable is to run at a speed of 10 kilometers (6.214 miles) an hour. Should this line prove successful, the system will be extended to others. The line is a single track, with turn-outs for cars to pass. The accompanying engraving, from *Le Genie Civil*, shows the arrangement of the cable conduit, rails, etc., as adopted for the road.

Slate Production.—The first bulletin issued by the Census Office for the census of 1890 concerns the production of slate in the United States, and has been prepared by Dr. David T. Day, of the Geological Survey. Slate is produced in 12 States and Territories, nine of which are on the Atlantic Coast. There is one quarry in Arkansas; one in Utah and two in California, but the production of these is very small. The principal slate regions are in Vermont and Pennsylvania, these two sections together producing more than three-fourths of the entire output. In all there are 206 quarries, and the total value of the slate produced last year was $3,444,863. In another year Tennessee will probably be added to the number of slate-producing States.

An English Passenger Steamboat.—The accompanying illustration, from the London *Engineer*, shows the passenger steamboat *Duchess of Hamilton*, recently built by Denny Brothers, of Dumbarton, Scotland, for the Caledonian Steam Packet Company. The steamer is 250 ft. long, 30 ft. beam, and draws 5 ft. 6 in. of water in ordinary working trim. She has a single stokehold with three boilers and seven furnaces; the engines are of the compound diagonal type, designed by Mr. Walter Brock, one of the partners of the firm.

The *Duchess of Hamilton* has extensive cabins below, and a promenade deck above, running the whole length of the ship. The passenger accommodations are unusually good for an English steamboat.



The contract speed was 17 knots an hour, but on the trial trip a speed of 18.1 knots was reached, the builders securing by this a premium of $15,000 over the contract price. In service she makes a run of 13½ miles in 38 to 40 minutes; being at the rate of 21.3 to 20.25 miles per hour.

The steamboat is employed on the line from Ardrossan across the Firth of Clyde to Brodick on the Island of Arran, running in connection with the trains of the Caledonian Railway. This service is very similar to that on Long Island Sound, near New York, and it is interesting to note the difference in type and general appearance between this boat and those used for like traffic in this country.

A Novel Pavement.—At a recent meeting of the Inventor's Institute, in London, a paper was read on road making by Mr. D. Nicoll. He proposed the use of blocks of granite 5 in. by 3 in., wrapped, except on the upper surface, with waste fiber and an elastic bituminous compound, and the whole brought together in a homogeneous condition while resting on a continuous pad formed of the same substance. This continuous pad or slab is taken to the ground and unrolled over the usual surface of concrete; the blocks are then placed diagonally and forced together. It is said that a horseshoe finds a ready hold for stopping or starting a vehicle, and that the noise is much less than with the ordinary slippery granite.

Railroads in Java.—The system of railroads in Netherlands India dates from the year 1862, when a concession was given by the Governor-General to the Netherlands India Railroad Company to build a road from Samarang to the independent states of Djokjokarta and Sourakarta, with a branch line to Cembarawa or Fort Willem I., which was completed in 1873. Two years previously, in 1871, the Government began preparations for constructing a line westward from Djokjokarta through Karang, Anjar, and Maos to Tjilatjap, which was not, however, opened for traffic until 1887; and from Djokjokarta eastward to Pasarouan via Sourabaya, with branches to Blitar, Malang, and Probolingo, which are also now in operation. On the Government lines the cost of construction has been, on an average, about 69,294 florins per kilometer, or $44,850 per mile.

On the west of the island concessions were given, in 1865, to the same company for making a road from Batavia to Buitenzorg, and in 1871, the Government took measures for the continuation of the railroad to Bandong in the Preanger residency. This has been completed, and, moreover, continued beyond to Garoet, with the intent to make a junction with the Djokjokarta line to Tjilatjap, the only port on the south coast of Java. It is understood that this railroad will be open for traffic within three years, though the prosecution of the work through the mountainous country in this part of the island necessitates much labor and expense in bridging, excavating, grading, and tunneling; Bandang and Garoet, for instance, lying at an altitude of over 3,000 ft. above the sea. A branch line from Batavia to Bekassi has lately been completed, and a short road to Tangerang is proposed, while a railway from Tagal to Margosari is also open beyond Banjaran. The cost of construction has therefore been, on an average, about 99,452 florins per kilometer, or $64,320 per mile.

Since 1875 the average annual expenditure on Government railroads and the new harbor works at Tandjong Priok has been between $2,800,000 and $3,200,000, not less than $32,000,000 having been paid during the decade following for this object alone. As regards the returns to the Government from these roads, it may be said that, until 1877, the only lines open for traffic were the private railroads between Batavia and Buitenzorg, of 30 miles, and the Samarang, Djokjokarta, and Cembarawa lines, of 126 miles. The company contracted to return to the Government the advances received during their construction, and to add thereto a share of the net profits. The amount thus paid increased gradually from $22,900 in 1871 to $408,000 in 1876, which sums have been paid over to the Government in Holland, through the corporation's agents there, while it has also declared an annual dividend of about 8 per cent. during the past 10 years for the benefit of its stockholders. The rolling stock on all of the lines is of small pattern, but built in durable though very simple style.

In Sumatra a line has been built by a private company to connect the several Delli tobacco plantations, and a branch is now being laid to Babougan. At Padang the Government has built a part of the line to Moera Kalabang for a distance of 34 miles to the base of the mountains, and is at present undertaking the most difficult portion, a three-railed track—such as is in use in Switzerland—being now necessary to reach the highlands. A thorough survey has been made of this region by a Government engineer, who has published a large work upon the mineral deposits in this region, in which he declares that there are extensive beds of coal of the best quality here, which lie near the surface of the land and may therefore be easily worked. It is expected, consequently, that the opening of this line will be attended by a great increase in the supply and by a cheapness of this article, which is now obtained at considerable expense from Australia, Japan, and England.

At the military station, at the northern point of Sumatra, there is an excellent steam tram-way in operation, similar to the lines in Sourabaya and Batavia. At the last-mentioned place the track is about seven miles in length, and extends through the principal streets of the city from the harbor to the suburbs, the tracks being double for the greater part of the distance. The locomotives are from the German works at Düsseldorf. They are provided with steam at the termini from stationary boilers. The steam enters the boilers at 200 lbs. pressure, and this supply proves sufficient for maintaining, with a train of four tram-cars, an average speed of 10 miles an hour, with stops at stations about half a kilometer apart. A dividend of 6 per cent. is declared annually. The net receipts for 1886–87, from all lines, were $1,938,400 and $1,788,200, respectively.—*Report of U. S. Vice-Consul Wood to the State Department.*

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(ESTABLISHED IN 1832.)

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NEW YORK, OCTOBER, 1890.

THE production of pig iron in the United States for the first half of 1890, according to the statistics collected by the American Iron & Steel Association, was 5,169,737 net tons—an increase of 754,653 tons, or 17.1 per cent., over the second half of 1889, and of 1,068,742 tons, or 26.1 per cent., over the first half of 1889. Nearly every iron-producing district showed a gain, and the total production was the largest ever reported for a half year.

The gain was entirely in iron made with bituminous coal or coke, the charcoal and anthracite furnaces showing a slight decrease. As might have been expected, the increase in the output of spiegeleisen and Bessemer pig was large, showing that a continually growing proportion of the pig iron made is intended for conversion into steel.

The leading iron-producing States were Pennsylvania, which furnished 49.2 per cent. of the total output; Ohio, 13.2 per cent.; Alabama, 8.9 per cent., and Illinois 6.8 per cent. The furnaces of the Southern States supplied in all 18.6 per cent. of the entire production.

THIS increased production of iron involves naturally increased consumption of ore; and we find, accordingly, that the shipments from the Lake Superior mines this year have amounted, up to the end of August, to 5,460,289 tons—an increase of 826,514 tons, or 17.8 per cent., over last year. An increased proportion of the ore comes from the newer districts; while the old Marquette Range supplied this year 33.1 per cent. and the Menominee Range 25.1, the Gogebic Range furnished 30.2 and the Vermilion Range 11.6 per cent. of the total shipments.

LAKE steamers are built with especial regard to their carrying capacity; and the extent to which this has gone will be appreciated when it is stated that the new steamer *Maryland* on a recent trip brought down the enormous load of 3,702 net tons of iron ore from Escanaba to Chicago. The ship's draft, with this great load, was 16 ft. 6 in.; she is 335 ft. long, 42 ft. beam and 24 ft. deep.

In this connection it may be noted that the new "whale-shaped" steamer *Colgate Hoyt*—which was illustrated in the September number of the JOURNAL—on her last trip brought 2,706 net tons of ore to Cleveland. With this load she made 13 miles an hour on Lake Superior.

THE latest project for quick transit between Europe and America has been brought forward by Canadian railroad men, who propose the building of a railroad from Quebec to St. Charles Bay on the Labrador coast. The road will be some 850 miles long, and it is believed that fast steamers can make the voyage from St. Charles Bay to Milford Haven in Wales in 3½ days. Some English capitalists are already interested in the project, and their engineer is making a preliminary examination of the route. One drawback is that the railroad line would run through an almost uninhabited and desolate country, and would have no local traffic whatever.

THE great tunnel under the St. Clair River, between Port Huron and Sarnia, is practically completed, and the trains of the Grand Trunk Railway will soon run through, without the delay heretofore required for the ferry transfer, which was often considerable in the winter.

This tunnel is in all 6,050 ft. long, 1,850 ft. being on the American side, 2,300 ft. under the river and 1,950 ft. on the Canadian shore. It is circular in form, the outer ring being 21 ft. in diameter and composed of cast-iron segments bolted together and lined with masonry. It carries a single track, and it is proposed to build a second tunnel of similar dimensions when a second track is required.

The tunnel is chiefly through blue clay, and was excavated by the Beach pneumatic shield, driven forward by hydraulic pressure, the work being carried on from both ends. The shield is forced into the clay and protects the workmen while they are excavating it and placing the iron segments. In building the tunnel 2,196,400 cub. ft. of earth were removed; 27,976 tons of cast-iron and 850,242 bolts were used. The segments were put in position by a balanced circular crane of very ingenious design attached to the rear end of the shield.

THE successful completion of the St. Clair Tunnel has stimulated projectors, and a company has been organized to build a similar tunnel under the Detroit River from Detroit to Windsor. This would be about 3,000 ft. long under the river, and the approaches would be about 3,000 ft. on either side, making a total length of about 9,000 ft. The top of the tunnel would be 48 or 50 ft. below the water level, or from 13 to 15 ft. below the river bed at the center. The estimated cost is $3,500,000 for a single-track tunnel, and the plan is to have it open to all connecting railroads.

THE armor-plate trials at Annapolis took place on September 18 and 22, three plates being tried, a compound steel and iron plate 10.6 in. thick, from Cammell, of Sheffield, England; a steel plate 10.5 in. thick from the Creusot Works, and a nickel-steel plate 10.5 in. thick, also from Creusot. Four shots were fired at each from a 6-in. gun at a distance of 30 ft., and one from an 8-in. gun, Holtzer steel forged projectiles being used, with brown cocoa powder. The plates were set up with 36 in. of oak backing.

The result of the first test—the four 6-in. shots—was the practical destruction of the Cammell plate, which was penetrated, cracked and badly broken, being practically destroyed. The Creusot plates stood the test remarkably well, being but little damaged, in fact, and barely penetrated at all.

The Board having the tests in charge will make a full report, which will be read with much interest.

THE sale of agricultural machinery in the Argentine Republic is very large, according to a correspondent of the London *Engineer*, and is likely to extend. He mentions especially plows, reapers and thrashing machinery, and recommends that wherever possible the frames of machines should be of steel, and that boilers should be made to burn straw, as fuel is scarce and dear. Cast steel should be used in place of cast-iron, in fact, as much as possible, as lightness is a great object. American machinery is generally preferred.

Machinery for working ramie, which is not unknown in this country, would be valuable, but the only machines yet introduced are of French manufacture.

A rural exposition will be held in Buenos Ayres in 1892, which will give a very favorable opportunity, as these expositions are largely attended. The letter is written for English manufacturers, but might give a useful hint to some of those on this side of the water.

THE Khojak Tunnel, on the Indian Frontier line, from Quetta to Candahar, which is now nearly completed, is one of the great tunnels of the world. It is 12,600 ft. long, and is built for a double track. It was worked from the ends and from two intermediate shafts, which are respectively 318 ft. and 290 ft. in depth. The chief obstacle met with in excavating it has been the quantity of water met with at different points.

This Frontier Extension is considered a very important line from a military point of view, and the Indian Government is spending a great deal of money upon it, in anticipation of the time when an English army at Candahar will be called on to face a Russian force from Merv, with the Transcaspian line behind it as a base of supplies.

THE so-called "Zone system" of passenger tariffs, which was adopted some time ago on the Hungarian State Railroads, has excited much attention in Europe from its simplicity, the entirely new principle upon which it is based, and the great reduction in passenger fares made by it.

Under this system the railroads are divided into zones starting from a given center, the first zone including all stations within a radius of 25 kilometers from the center, while the remaining zones are 15 kilometers in width up to the fifteenth, that and the sixteenth each taking in a belt of 25 kilometers. The rates are established by zones, the fare from a station in any one zone to one in any other being found by multiplying the established unit by the number of zones to be crossed.

The system reduced rates largely, the reduction increasing with distance, and varying from a small amount for short distances to 90 per cent. for the longest distance, about 225 kilometers. The immediate result has been that passenger business on the Hungarian lines has more than doubled, and the gross receipts have increased, in spite of the reduction in rates.

IT is reported that the Chinese Government has finally decided to build a strategic railroad from Pekin to the Manchourian frontier, the object being to aid in the colonization of Northern Manchouria and to make it possible to move an army to the frontier in case of need. The report has not yet been confirmed, but if true, the moving cause is doubtless the fear that the Russians will push forward the Siberian Railroad and so place themselves in readiness for a movement into Chinese territory should they wish to make one.

Should the proposed line be built it may become an important line commercially, and aid in increasing the overland traffic between China and Russia, which is already large, both in amount and value, with the present imperfect means of transport.

A RAILROAD across the Sahara, from some point on the Algerian railroad system to Timbuctoo, is proposed, and French engineers have made some preliminary reconnoissances. The line, it is claimed, will draw to itself a considerable commerce, will promote and consolidate French influence in the Western Soudan, and will lead to the settlement of parts of the Sahara, which is not by any means the irreclaimable desert which the geographies of a few years ago asserted it to be. The line presents no great engineering difficulties.

THE Trans-Caspian Railroad, built by the Russian Government as a military line, is developing much commercial importance. As it followed substantially a line which has been a highway of commerce for centuries, it has taken the traffic formerly carried by caravans, and it is also doing much toward increasing the products of the country on its line, by furnishing them an outlet to market. The receipts of the road from commercial business in 1889 were 2,800 000 rubles, and so great has been the growth this year that it is estimated that they will reach more than double that amount, or 6,000,000 rubles.

THE Engineers of the Pennsylvania Canal Commission have very nearly completed preliminary surveys for the proposed ship canal, which is to connect the Ohio River with Lake Erie. Several lines have been run, the latest extending from the Ohio at Rochester to Lake Erie at Conneaut Harbor, with an alternate line to Elkwood Creek. The length of this line is a little over 100 miles, but not all of it would have to be canal, as the survey contemplates the use of the Beaver and Shenango Rivers by a system of locks and dams. It is understood that the Commission will report that there is ample water supply for a ship canal, and will recommend sites for several storage reservoirs. This report will be submitted to the Legislature as a basis for action on the canal project.

THE latest plan for crossing the British Channel and making a connection between the French and English railroads has been proposed by M. Bunau-Varilla, and is intended to obviate the political and military objections made to a tunnel, and at the same time the reasons given against a bridge crossing proposed by Messrs. Schneider and others. These objections were the great cost; the danger to navigation from the erection of bridge piers, and the fact that, as the bridge would cross the high seas which are under no one national jurisdiction, the consent

of all the maritime powers would be needed to its construction. M. Varilla proposes to build at either side of the Channel a bridge extending out to such a distance from the shore as may be determined by more careful surveys, and to build a tunnel under the central portion of the Channel. The connection between the bridge sections and the tunnel will be made either by inclined planes or by hydraulic elevators capable of transferring a whole train at once. He considers that the construction of the bridge sections will present no remarkable difficulties, since they will be in shallow water, while the transfer arrangements and the building of the tunnel can be easily managed. He thinks also that this arrangement will meet the objections made from a military point of view, since the bridge approach could be easily destroyed by a warship in case of necessity.

It has always seemed to us that these military objections to the tunnel amount to very little, since an invading army would be hardly likely to undertake a march through a passage which could be flooded in a few minutes, to the certain destruction of every one who might happen to be in it. They have always been urged in England, however, against the project for tunnelling under the Channel, and has been sufficient to defeat a bill granting the necessary permission in Parliament.

FROM a statement lately made to the general convention of German iron-workers, it appears that since 1886 there have been 1,668,179 metal ties laid on the Prussian State Railroads. During the fiscal year 1889-90 provision was made for laying about 600,000 more.

It also appears from the same statement that the average price for iron ties was $25.83 per ton (of 2,000 lbs.); for the clips or chairs for holding the rails, $65.38, and for the bolts, etc., $63.86 per ton.

At these rates ties of the Berg & Mark pattern, weighing 54 kg. (119 lbs.) each, cost, for the tie, $1.55 and for the fittings, 17 cents, a total of $1.72. Ties of the Hartman pattern, weighing 53 to 57 kg. (117 to 125 lbs.), cost from $1.50 to $1.62 for the tie, and 39 cents for the chairs, etc.; a total of $1.89 to $2.01 each. The results so far obtained have been very satisfactory.

THE interest felt in Europe in the canal system is shown by the International Congress on Inland Navigation, the fourth meeting of which was recently held at Manchester, England, the previous meetings having been at Brussels, Vienna and Frankfort. At this Congress all the leading European nations were represented, and papers were presented bearing on the subject of Inland Navigation in England, France, Belgium, Germany, Austria, Italy, Holland, Russia and America.

The importance of maintaining and improving the inland water lines was very strongly urged, and figures were presented showing an increase of canal traffic almost everywhere, in spite of the competition of the railroads. The subject which is now engaging the attention of canal engineers everywhere seems to be some improved method of traction, and interesting statistics were presented and accounts given on experiments made in this direction.

THE *Indian Engineer* has received from a correspondent a photograph of an old gun which is now lying in the jungle near the town of Bishenpoor in Bengal. Its history is not known, but it is believed to antedate the English occupation of the country. The bore of this gun is 11¾ in.; its length, 11 ft. 9 in.; the outside diameter at the muzzle, 19 in., and at the touch-hole, 29 in. It will probably weigh over six tons. It is in perfect condition except the natural wear from rust, etc. The point of the description is, that the gun is made of wrought iron *in coils*—which is perhaps another verification of the wise man's assertion that there is nothing new under the sun.

JUDGING from the reports of their proceedings, the general drift of opinion in the local engineering societies seems to be in favor of a limited or federal union with the American Society, but opposed to any organic union which will deprive them of their independence or make them simply chapters or branches of the central association. Most of them were to have representatives at the annual meeting of the American Society, but the conference then held was without any results.

Some form of union or alliance seems very desirable, and if an arrangement can be made which will secure co-operation and close friendly relations, it is by no means improbable that it will be found to work so well as to lead to a desire for still closer relations hereafter.

THE new steamer *Majestic* of the White Star Line is one of the first large ocean steamers to be completely lighted by electricity. She is provided with two separate dynamos placed in different compartments, so that the facilities for lighting are not likely to be cut off. The electric light wires extend to every part of the ship, and there are in all about 1,200 incandescent lamps of 16 candle power.

ENGLISH AND AMERICAN LOCOMOTIVES.

THE *Engineer* of September 5 contains another controversial article on the relative merits of British and Yankee locomotives, in which the writer says that he has derived amusement in endeavoring to reconcile some of the admissions made by his adversary—the editor of *Engineering News*—in one article with his endeavors to put them in another light in succeeding articles. If that sort of perplexity affords amusement to our Anglican contemporary there is probably an unlimited amount of it in store, should the discussion with the American purveyor of engineering news be continued. Thus far the dispute has not been very edifying, but it has been entertaining, and has been remarkable chiefly for statements of facts which are doubtful or not so.

The *Engineer*, in its last article, says: "The whole discussion turns on whether a locomotive boiler has to generate more steam in a given time in America than in England," and then makes the statement that "careful experiment has shown that an average performance (of English locomotives) is 500 lbs. of steam per square foot of grate per hour."

Here is a chance for the editor of the *News*. When the *Engineer* asks him to rise and "explain precisely in what way and how the American engine is a better all-round machine than ours;" or when the British disputant suggests that its American adversary "should take boilers first, and the whole practice of making steam, and the method of firing with bituminous or semi-bituminous coal, comparing English and American methods together, pointing out the defects of the former and the advantages of the latter," the questions at issue are more or less indefinite. Even when the *Engineer* says that American locomotives

do not evaporate more than from 5 to 7 lbs. of water per pound of coal, whereas English locomotives evaporate from 7 to 10 lbs., the question at issue is still vague because nothing is determined about the quality of coal, loads hauled, speeds, or size and weight of engine and boiler. But when the writer says that an *average* performance of an English locomotive boiler is the generation of 500 lbs. of steam per square foot of grate per hour, he exposes his abdomen. But the editor of *Engineering News* is a serious-minded person, and he may inquire what his transatlantic opponent means by "*average* performance." If it means that all the locomotives on an English railroad evaporate on an average 500 lbs. of water, while in service, it cannot be true. If it means that *some* of the locomotives average that amount of evaporation *while running*, then that performance is considerably below what many American locomotives are doing. We may take the figures we gave last month of the performance of locomotives on the Grand Trunk Railway. The average evaporation reported then was 7.35 lbs. of water per pound of coal. The average consumption of coal was 121.6 lbs. per square foot of grate per hour. Consequently, 893.7 lbs. of water were evaporated per hour per square foot of grate.

During last March, April and May a careful record was kept of the performance of a passenger locomotive on the Hudson River Railroad during 66 runs between New York and Albany, a distance of 143 miles. This road, as most of our American readers will know, is nearly level over its whole length, so that heavier trains can be drawn than on most other roads. The steepest grade is one of 26 ft. per mile, which is about a mile long.

The locomotive was of the American type—that is, with four wheels coupled and a four-wheeled truck, with 18 × 24-in. cylinders and 70-in. driving-wheels which carried a load of 60,500 lbs. The grate was 72 × 35⅜ in. = 17.68 square feet of area. The trains consisted of 6, 7, 8 and 9 cars. The weights were as follows:

Engine	94,500 lbs.
Tender (average)	44,000 "
Buffet Car	79,000 "
Sleeping Car	83,000 "
Compartment Car	94,500 "
Sleeping Car (16 sections)	95,000 "
Dining Car	80,000 "
Drawing-Room Car	71,000 "
Weight of 6-car train	641,000 "
Sleeping Car	63,000 "
Weight of 7-car train	704,000 "
Sleeping Car	63,000 "
Weight of 8-car train	767,000 "
Sleeping Car	63,000 "
Weight of 9-car train	830,000 "

There were 36 trains with 6 cars, 19 with 7, 11 with 8 and 1 with 9 cars.

The average consumption of coal for the 66 runs was 49.46 lbs. per train mile, and the average running speed 42.77 miles per hour—consequently the average consumption of coal was 119.6 lbs. per square foot of grate per hour. The coal used on the Hudson River Railroad is of poor quality, which, taken with the heavy loads hauled made the rate of evaporation only 6.18 lbs. of water per pound of coal. Consequently, the average evaporation for the 66 runs of 143 miles each, or a total of 9,438 miles, *was* 739.12 *lbs. of water per square foot of grate per hour*. The highest average evaporation for one trip was 7.80 lbs. of water per pound of coal, and the lowest 5.38. The highest average speed was 47.93 miles per hour, and the lowest 37.3. With the nine-car train, the engine evaporated an average of 868.29 *lbs. of water per square foot of grate per hour*. To show the influence of load on the rate of evaporation an experiment was made with an engine and tender which was run from New York to Albany without a train. It consumed 18.06 lbs. of coal per mile, or more than a third as much as was burned hauling the heavy trains, and *it evaporated* 9.19 *lbs. of water per pound of coal.*

Or, take the performance on the Baltimore & Ohio Railroad reported in our August number. In the experiments which were made the quantity of water evaporated per lb. of coal was not given. If it was as great as the rate of evaporation in the Grand Trunk experiments—and it probably was at least equal to that, as the coal used on the Baltimore & Ohio road is of excellent quality—the engine would have evaporated 1,423.7 lbs. of water per square foot of grate per hour, or nearly *three times* what the *Engineer* says is the *average* performance of English locomotives. What was done on the mountain grade of the Baltimore & Ohio road is not given as *average*, but as *maximum* performance. It takes just about an hour for trains to run up the 17-mile grade from Piedmont to Altamont, and probably that rate of combustion and evaporation is equalled nearly every day on that part of the road. So far as the questions at issue are concerned, the important point is the *maximum* capabilities of the engines. On nearly all our roads the locomotives probably maintain a rate of evaporation as high as that reported on the Baltimore & Ohio line for short periods of time. If they are not able to do this, in railroad vernacular, they will "stick fast," and fail utterly.

Our English contemporary says: "Our locomotives, both passenger and goods, are worked as hard as they can be worked." Now, if when they are so worked they can evaporate only an average of 500 lbs. of water per square foot of grate, they are obviously inferior to Amercian engines, which evaporate nearly twice as much, and on a pinch can convert nearly three times as much water into steam as the English engines do.

The *Engineer* asks: "What is the average performance of an American boiler?" We ask what is the maximum performance of an English boiler? If it is as much below that of American boilers as the average performance is below the average here, the English engine is much inferior to the American machine for the traffic of this and of other countries. In fact, if the English engine is what its advocate says it is, it is totally incapable of doing our work.

We have pointed out that the quantity of water evaporated per pound of coal depends very much on the rate of evaporation. If the boiler is forced to its utmost, the rate will be lower than it will be if the combustion is slower. Now, is it economical to increase the coal consumption in proportion to the water evaporated, in order to haul heavier trains?

Without going into elaborate or confusing figures, it may be stated as a general proposition that, when coal is cheap—that is, when the price does not exceed $1.75 per ton—the cost of train service, including the engineer, fireman, conductor and brakeman, exceeds that of fuel; therefore, if we make our engines do ten per cent. more work, we save more in train service than we would gain if we pulled ten per cent. less train and burned ten per cent. less coal. Besides train and engine service there are other

expenses which are lessened, such as interest on the additional equipment which would be needed if it did less work, including shops, care while not in service, etc. The purpose of a locomotive is to do work, and its efficiency is measured by its capacity for hauling trains, and of keeping in service as many days and running as many miles in a year as possible.

The *Engineer* says that the discussion thus far shows (1) that American coal is inferior to English coal, and (2) American firemen are not equal to their English brethren. The only reply one can make to this is, perhaps: Some is, or are—whichever is grammatical—and some is or are not. The character of American coals and firemen differ very much from each other, so that it does not seem worth while to make a general comparison, but probably if an English fireman should undertake to fire a consolidation or express engine while running up the grade west of Piedmont on the Baltimore & Ohio, or Altoona, on the Pennsylvania Railroad, he would get an experience he never had before.

Further, our contemporary summarizes by saying that the discussion shows that it costs more for fuel to haul heavy trains at slow speeds than would the haulage of lighter trains at higher speeds. Our assertion is that, while it may cost more for fuel, the total cost is less, and that is the important consideration with a railroad company.

Lastly, the writer in the *Engineer* concludes what he chooses to call the "defects" of the American locomotive "are the result of the conditions under which it is worked, not of defects in design or construction, or in want of adaptability to the work it has to perform." It is not easy to understand just what that means. If it is intended to say that American locomotives have been designed and constructed to do the work which they are intended to do, it is undoubtedly true, and if the converse proposition is asserted, that English locomotives are not designed or constructed so as to be capable of doing as much work as American locomotives, it would also probably be true. If, as the *Engineer* says, their locomotives, both passenger and goods, are worked as hard as they can be worked, and if, when they are thus worked their average production of steam does not exceed 500 lbs. per square foot of grate per hour, then it is plain from the data we have quoted that the British iron-horse has not as much bottom as his American congener.

Mire is not as common in London or Glasgow roads as it unfortunately is on some American streets, but if such obstruction to travel does exist there, it is doubtful whether a brewer in either of those cities would find a horse which could not pull his beer-wagon out of a "mud-hole" as valuable as one which could, even though the latter should consume more oats than the former.

But the question of the relative economy of feed of the two breeds of iron-horses, as stated by our contemporary, is not conceded. The difficulty is to make comparisons of the performance of engines under like conditions. To make fair comparisons, the weight and dimensions of engines and trains, the speeds and grades and other circumstances must be known. If our contemporary would give us some reports of carefully conducted experiments, it would throw some light on the subject. But why not adopt the suggestion made in our last number—let the *Engineer* and *Engineering News* each submit a design of locomotive to their readers for comparison and criticism. It will then be their readers' turn to be amused.

TWO VALUABLE WATERWAYS.

WHILE in many parts of the country there has been a disposition to abandon the artificial and even the natural waterways, and to allow them to be superseded by the railroads—a disposition much to be regretted for many reasons—a notable exception is to be found in the two canals which connect Hampton Roads with the extensive system of sounds and rivers of Eastern Carolina.

The older of these is the Dismal Swamp Canal, which extends from the Elizabeth River south of Norfolk to the Pasquotank River in North Carolina, and which is one of the oldest artificial waterways in the country. Chartered first in 1785, its seven locks, 100 × 18 ft. in size, were considered engineering feats in their day, and are still in constant use.

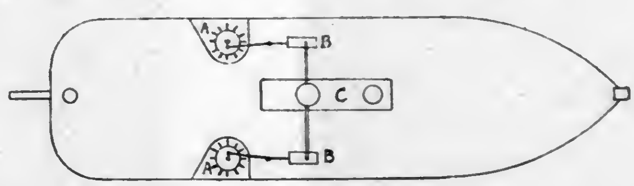
The other, the Albemarle & Chesapeake Canal, is shorter, but of larger section. It extends from the Elizabeth River to the North Landing River and has the advantage of the older work not only in size, but in the fact that it has but a single lock—240 × 95 ft. in size—and that a tidal lock, which has to be closed only at certain stages of water and in certain directions of the wind.

To equalize the conditions somewhat, the Dismal Swamp Canal Company has recently undertaken improvements which will much increase its capacity. These include an enlargement of section and the cutting down of the summit level, so as to dispense with several of the locks, and have really been made necessary by the increasing traffic.

The commercial importance of these canals can be seen from the fact that they brought to Norfolk last year 87 per cent. of the logs which supply the great lumber mills of that city, a very large proportion of the other forest products reaching the port, a considerable part of the corn, rice and naval stores, besides carrying a large traffic in merchandise southward bound.

Besides their commercial importance, these canals would be of great strategic value in case of war. A reference to the map will show how extended their water connections are and how much farther still they might be made to reach. It is to be hoped that before long improvement and extensions will be undertaken which will give, at a comparatively small outlay, an inland waterway from New York Bay to Florida, which might be of almost inestimable value in time of war, and which is sure to be commercially worth much more than its cost.

In this connection it may be of interest to note that a very early attempt at steam navigation on canals in this country was made on the Dismal Swamp Canal. The boat and its machinery were designed by Mr. Harris and by Lieutenant W. W. Hunter, of the United States Navy,



about 1840, and were for a time operated by Commodore Marshall Parks, who is still a resident of Norfolk. The boat is shown in the accompanying diagram, which is prepared from a sketch made by Mr. Parks. There were two wheels placed horizontally in semi-circular recesses cut in the sides of the boat; these wheels were simply drums

having paddles on their circumferences and driven by engines attached directly to the upper end of the vertical shafts. In the sketch *A A* are the wheels, *B B* the engines and *C* the boiler.

This boat was run for a considerable time, and was at one time taken up as far as New York. She was not altogether successful, however, and no more of the same pattern were built.

NEW PUBLICATIONS.

ELECTRO-CHEMICAL ANALYSIS: BY EDGAR F. SMITH, PROFESSOR OF ANALYTICAL CHEMISTRY, UNIVERSITY OF PENNSYLVANIA. Philadelphia; P. Blakiston, Son & Company (116 pages, 25 illustrations; price, $1).

This book is intended for students of analytical chemistry who wish to become acquainted with the methods of quantitative analysis by electrolysis; a class which is continually increasing in number as those methods acquire greater importance and come more generally into use.

The plan adopted by the Author has been to outline briefly the action of the electrical current on the different acids and salts; the various sources of electrical energy; its control and management; the history of the introduction of the current into chemical analysis. This introduction is followed by sections on determination and separation of metals and the oxidations possible by means of the electric agent. The section on each metal is accompanied by references to the history of that metal.

The methods given preference have been selected from all sources after long experience, and after tests have shown them to be reliable. The book has evidently been prepared with great care, and must prove a valuable assistant both to the student and the working chemist.

THE HALL SIGNAL COMPANY: ILLUSTRATED CATALOGUE. New York; issued by the Company.

This Company has issued a new book which describes their system of signals very completely. The titles to the different sections will give an idea of the contents. These are Block Signaling, Automatic Block Signaling, Form and Color Signals, Semaphores and Disks, Distant Signals, Trains Breaking in Two, Track Circuit Signals, Objections to Permissive Blocking, Mechanical Construction, Description of Instruments, Block Signal Circuits, Signals for Permissive Blocking, Electric Interlocking, Single-Track Block Signaling, Electric Interlocking Instrument, Principles of Electric Interlocking, Applications of Electric Interlocking, Automatic Signals for Highway Crossings, Audible Highway Crossing Signals, and Highway Crossing Gate Signals. These subjects are all treated in a very clear and comprehensive way. The book is very elaborately illustrated with wood engravings by Bartlet & Company, is printed in large, clear type, and on excellent paper. The cover is made of paper which looks like sheet iron, on which the name of the company is stamped in relief in handsomely designed lettering. The chief fault of the book is that the pages, which are 12 × 17 in., are inconveniently large, so that it is impossible to read them with comfort without a desk or table to spread the book on. In these days of rapid accumulation of printed matter convenience of stowage ought to be considered in printing a book. The puzzle is to know what to do with the copy sent us, as it will not go on the shelves of a bookcase, and is too thick to be stored with drawings. Most of the engravings could have been printed on a page half as large, and those which are too big might have been reduced in scale and not have lost materially in clearness. Excepting in its size the volume is an admirable example of a descriptive catalogue, and an illustration of the fact, to which attention has been repeatedly called, that much of the best technical literature is now to be found in trade catalogues.

TESTS OF A COMPOUND LOCOMOTIVE: BY GEORGE H. BARRUS, M.E. Philadelphia.

A pamphlet of 55 pages has recently been issued by the Baldwin Locomotive Works, containing a report of Mr. Barrus, who was employed by that Company to make a series of tests of the compound locomotive built in those works, and which has been at work on the Baltimore & Ohio Railroad.

The main and most important fact brought out in these experiments was that, in two runs from Philadelphia to Washington and return, a distance of 266 miles, one of them by the compound locomotive, and the other by an ordinary engine of substantially the same design and dimensions, excepting the cylinders, the compound engine burned 14.9 per cent. less coal than the ordinary engine. Assuming that this truly represents the economy of the compound engine over the simple one, is it sufficient to warrant the use of the former type of locomotive instead of the latter? If coal costs from $1 to $1.50 per ton, a locomotive will burn from $1,500 to $2,500 worth in a year. Calling the saving by the use of compound engines 15 per cent. it would amount to from $225 to $375 per year. As an offset to this there would be the interest on the extra cost of the compound, which is about $500. Ten per cent., which any prudent business man would charge on this, would be $50, so that the saving will be reduced to from $175 to $325.

Another important consideration in this connection is the endurance of compound locomotives—that is, can you get as many days' or miles' service in a year out of a compound engine with four cylinders and some additional complication in the valve-gear and steam-pipes as a simple engine will give? Laying up a locomotive when it is badly needed is very expensive and often results in serious loss to a railroad company. Will the economy stated compensate for the risk of a loss of service, to say nothing of some additional cost of repairs?

But even the economy reported seems to be doubtful. The only comparison of the performance of the two engines in the report before us, which it seems possible to make, is that of the two runs with the Washington limited express. The curious fact appears in this that the boiler of the compound engine evaporated 6.06 lbs. of coal per pound of water, while the simple engine evaporated only 5.37 lbs. It is also reported that the compound consumed 84,506 lbs. of water in making the round trip, and the other engine consumed 88,040 lbs. Obviously, then, it took 88,040 lbs. of steam to do the work in the simple engine that was done by 84,506 lbs. in the compound. If the boiler of the simple engine had generated steam as economically as that of the compound—that is, if it had evaporated 6.06 lbs. of water per pound of coal instead of only 5.37 lbs., then the simple engine would have consumed only 14,528 lbs. of coal instead of 16,389 lbs., the actual consumption. As the compound engine burned 13,942 lbs. the difference in its favor would then have been only 4¼ per cent. In other words, the economy of the compound, from the report before us, seems to be due more to the boiler than to the engine.

The data regarding the working of the two engines are given in much detail in the report, and the conclusion is stated that "the effect of the reciprocating parts, although weighing more than those of the simple engine, appeared to be inappreciable, and judging from the manner in which the new engine operated during the progress of the tests, it meets all the mechanical requirements demanded by a successful locomotive."

POOR'S HAND-BOOK OF INVESTMENT SECURITIES: A SUPPLEMENT TO POOR'S MANUAL OF RAILROADS; JULY, 1890. New York; H. V. & H. W. Poor.

This book includes the tables heretofore published in *Poor's*

Manual, with some additions; its nature can best be indicated by a brief statement of its contents. These include tables showing the coupons on bonds which become due each month in the year, with the places of payment; usual dates of dividends, times of holding annual meetings, and places of stock registry of all leading railroad companies; dividends paid by railroad companies from 1886 to 1889, inclusive, and also from January to July, 1890; ranges of active stocks and bonds on the New York, Boston, Philadelphia, and Baltimore exchanges from 1886 to 1889, inclusive, with supplemental tables showing the ranges of prices from 1878 to 1885; list of bonds maturing in the 10 years 1891-1900; list of leading railroad companies, with location of their general and transfer offices; statement of all securities listed on the New York Stock Exchange.

This will give a very fair idea of the contents of the book, and will indicate its value to banks, bankers, brokers, and, indeed, to all who are interested in railroad securities either as dealers or investors, and this certainly includes a very large class of the community. The book has been carefully prepared by the publishers of the *Manual*, who have exceptional facilities for the work.

POCKET DIRECTORY FOR 1890: A COMPLETE LIST OF NEWSPAPERS, MAGAZINES AND PERIODICALS IN THE UNITED STATES AND CANADA. Chicago; Lord & Thomas.

This little book seems to be what the publishers have designed to make it—a complete list of the periodicals of the United States and Canada, with some facts, briefly stated, as to their character, circulation, etc. In a newspaper office it is almost indispensable, and to advertisers of all classes it must be extremely useful.

HANDY LISTS OF TECHNICAL LITERATURE: PART III, ENGINEERING AND MECHANICS: COMPILED BY H. E. HAFERKORN AND PAUL HEISE. Milwaukee, Wis.; Heise & Haferkorn (price, paper, \$2.50; cloth, \$2.75).

This is intended to be a list of all books in the English language on subjects connected with engineering and mechanics, published since 1880, and is supplemented by a list of periodicals treating the same class of subjects.

The preparation of such a work is no light task, and it is impossible to say how completely it has been done until the book has been in use for some time. A short examination, however, indicates thorough and careful work, and the *List* will be of great service to the engineer, the student, and the editor as a book of reference and constant desk companion.

The extent of the work will be apparent, when it is stated that it contains the titles of nearly 2,200 books and papers, with references to their authors and publishers. It is brought up to the latest date, including many books published in the present year.

BOOKS RECEIVED.

REPORT OF TESTS OF A COMPOUND LOCOMOTIVE (S. M. VAUCLAIN'S PATENT) BUILT BY THE BALDWIN LOCOMOTIVE WORKS AND IN SERVICE ON THE BALTIMORE & OHIO RAILROAD: BY GEORGE H. BARRUS, M.E. Philadelphia; published for Burnham, Parry, Williams & Company.

SELECTED PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; published for the Institution. The papers last received include the following: Coasts and Rivers of Yesso, by C. S. Meik; Artesian Wells in South Lincolnshire, by John Charles Gill; Keswick Water-power Electric Light Station, by W. P. J. Fawcus and E. W. Cowan; Welding by Electricity, by Sir Frederick Bramwell; Wire Ropes, by Andrew S. Biggart; Probable Errors of Surveying by Vertical Angles, by Wilfrid Airy; the Screw Propeller, by Sydney Walker Barnaby.

A second installment of these papers includes the following: Deflection of Spiral Springs, by Alfred E. Young; Distributing Triangulation Errors, by A. E. Wackvill; Barytes and Umber Mines and Refining Mills, by Percy L. Addison; the West Hallington Reservoir, by C. G. Henzell; Applications of Electricity in Engineering Workshops, by Charles F. Jenkin; Railway Stations and Yards, by Richard M. Parkinson; the Calliope Graving Dock at Auckland, N. Z., by J. H. Swainson; Abstracts of Papers in Foreign Transactions and Periodicals.

PROTOCOLS OF PROCEEDINGS OF THE INTERNATIONAL MARINE CONFERENCE, HELD IN WASHINGTON, D.C., UNITED STATES OF AMERICA, OCTOBER 16–DECEMBER 31, 1889: VOLUMES I, II, III. Washington; Government Printing Office.

LIST OF MERCHANT VESSELS OF THE UNITED STATES: PREPARED BY THE BUREAU OF NAVIGATION, TREASURY DEPARTMENT. Washington; Government Printing Office.

HERZOGLICHE TECHNISCHE HOCHSCHULE CAROLO-WILHELMINA ZU BRAUNSCHWEIG: PROGRAMME FOR THE SCHOOL YEAR 1890–91. Brunswick, Germany; issued by the School.

PRACTICAL TREATISE ON INJECTORS AS FEEDERS OF STEAM BOILERS: FOR THE USE OF MASTER MECHANICS AND ENGINEERS IN CHARGE OF LOCOMOTIVE, MARINE AND STATIONARY BOILERS: BY GEORGE H. NISSENSON, ENGINEER. New York; published by the Author (74 pages, illustrated; price, 50 cents).

THE SEWERAGE OF COLUMBUS, O.: ADDRESS BY COLONEL GEORGE E. WARING, JR., AT THE BOARD OF TRADE AUDITORIUM, JUNE 23, 1890; WITH DISCUSSION FOLLOWING. Columbus, O.

WESTON STANDARD VOLTMETERS AND AMMETERS FOR DIRECT CIRCUIT CURRENTS: ILLUSTRATED CATALOGUE. Newark, N. J.; the Weston Electrical Instrument Company.

REPORTS FROM THE CONSULS OF THE UNITED STATES; NO. 117, JUNE, 1890. PREPARED BY THE BUREAU OF STATISTICS, DEPARTMENT OF STATE. Washington; Government Printing Office.

THE PRESERVATION OF IRON STRUCTURES FROM RUST: NATURE AND COMPOSITION OF BAR AND CAST IRON AND THEIR BEHAVIOR UNDER THE INFLUENCE OF THE ATMOSPHERE, MOISTURE, ACIDS, ETC. Brooklyn, N. Y.; issued by J. H. Tiemann.

ABOUT BOOKS AND PERIODICALS.

IN the JOURNAL of the Military Service Institution for September, Captain Mills's notes on India, China and Japan are continued; there are articles on Infantry Fire Tactics, by Lieutenant Howard; Recent Japanese Manœuvers, by General Abbot; Light Artillery Target Practice, by Lieutenant Hawthorne; Infantry Ammunition on Battle Field, by Lieutenant Beckurts; Diet of the Soldier, by Surgeon Waters. The series of historical sketches of the Army is continued by a History of the Fourth Regiment of Artillery, written by Lieutenant A. B. Dyer.

Among the many magazines of the day one, at least, is free from sensationalism and doubtful fiction. OUTING unweariedly preaches the gospel of wholesome living, and the numerous bright and breezy articles in its September number treat of outdoor sports and games, manly—and womanly—exercise and similar topics in a way that makes it most interesting reading.

The latest quarterly number of the PROCEEDINGS of the United States Naval Institute contains papers on Navy Boats, by Ensign A. A. Ackerman; Desertion, by Lieutenant A. McCrackin; the Howell Automobile Torpedo, by E. W. Very; and Admiral S. B. Luce's paper on Naval Training, with the

extended discussion on the same. There are also some interesting professional notes of minor importance.

The August number of the JOURNAL of the American Society of Naval Engineers has papers on the Double-screw Ferry-boat *Bergen*, by Chief Engineer Isherwood, U.S.N.; on Boiler Tubes, by Passed Assistant Engineer R. T. Hall; on Continuous Current Dynamos, by Professor Jamieson. The discussions on Speed Trials of Fast Ships and on Tubulous Boilers are continued, the latter being chiefly made up of an account of the Belleville boiler, by Mr. Miers Coryell, who ably advocates the claims of that boiler.

A new monthly, the field of which is indicated by its name—PAVING AND MUNICIPAL ENGINEERING—has been started in Indianapolis, with Mr. William Fortune as Editor. The current issue has several very interesting articles, and there are some contributions of note on the list. The field is one that has not been filled properly by existing journals, perhaps, and our new contemporary, we hope, will meet with deserved success.

In BELFORD'S MAGAZINE for September serious economic questions find room, as well as the usual quota of fiction and lighter matters, and there are a number of articles that will stand a careful reading. An interesting feature of this magazine are the short articles on current topics, some of which are excellent specimens of condensed argument.

A new venture is the AMERICAN SHIPBUILDER, of New York, a weekly paper edited by Messrs. G. Foster Howell and David L. Bradley, and intended for shipbuilders, shipowners, marine architects, and engineers. The first number has eight pages and contains an excellent variety of news and technical articles, with an illustrated description of the new lighthouse steamer *Azalia*.

In SCRIBNER'S MAGAZINE for September Professor N. S. Shaler has the first paper of a series on Nature and Man in America. Mr. Russell Sturgis's recent paper on the City House is supplemented by one on the Country House by Donald G. Mitchell. Life on a modern cruiser is described and illustrated by Mr. Zogbaum in a very entertaining article, and Mr. Thomas Stevens gives a general description of African River and Lake Systems.

Municipal Government; Taxes; the Race Question and some of the difficulties now besetting the Dominion of Canada, including the railroad question, are among the subjects discussed in the ARENA for September, while less material matters have their full share of space for the month.

AROUND HAMPTON ROADS.

THE ancient seaport city of Norfolk has in recent years shown signs of very substantial progress, and to a visitor the improvement is very marked, the number of substantial buildings and new wharves indicating the increase of the city's business. Several causes have contributed to this growth, among which may be mentioned the extension of the railroad systems which find their terminus there; the building of new railroads; the excellent water connections of the city; the growth of the surrounding country, and the improvement of the harbor, the channel now having a depth of 25 ft. at low tide up to the city wharves and the Navy Yard.

The extensions of the Norfolk & Western Railroad have made it an important coal and mineral line, as well as a cotton carrier. To serve the coal traffic the road has built a very fine pier at Lambert's Point, a little below the city, where last year over 1,000,000 tons were delivered, and growing business has made necessary recently the erection of new piers for merchandise and general freight at the same point. The new railroads recently completed to Norfolk include the Atlantic & Danville, running eastward to Danville, Va., and the Norfolk & Carolina, which runs southward into the lumber district, and which is still being extended. The Virginia Beach Railroad not only serves for pleasure travel, but also brings in a considerable local business.

Norfolk last year shipped over 500,000 bales of cotton, but although it has been popularly known chiefly as a cotton port, this is not by any means a measure of its business. The receipts of grain of various kinds and tobacco were large. The coal receipts have been mentioned above, and the port has already begun to receive a considerable amount of iron from the Southern furnaces. The shipments of vegetables and fruit from the truck farms about the city also form an important business. The chief single interest, however, is the lumber business, and several mills of very large capacity have been established for the manufacture into lumber of the logs which reach the city partly by rail, but to a great extent by canal. This business is continually growing, and its success here is secured by the fact that there is a practically inexhaustible back country to draw upon for supplies of logs, and that a very large part of this forest region can be reached by water. The growth of the timber in this section is quick, and the supplies are renewed so fast that there is no danger that the forest will be destroyed.

Apart from the lumber interests Norfolk is not yet a manufacturing city, although it presents many advantages in that respect, owing to its command of cheap supplies of coal, lumber, cotton, etc., and also to the abundant supply of labor. A commencement in this direction has been made in the establishment of a large knitting mill in the suburb of Berkeley, which is now in successful operation, and which is provided with machinery of the latest patterns; while other establishments will soon be added. Apart from the factories the chief need of Norfolk at present is additional wharf facilities. The construction of new docks on the water front has been delayed by various local causes, but arrangements are now being made to supply this want.

NEWPORT NEWS.

Newport News may be considered as practically a suburb of Norfolk, from which it is distant 12 miles by water. It is the terminus of the Chesapeake & Ohio Railroad, and considerable shipments of cotton, tobacco and grain are made from this point, but while it has advantages in the way of deep water, etc., the harbor has not the shelter which is provided at Norfolk, and the growth of the town outside of the railroad piers has been comparatively slow.

A very large manufacturing establishment has been begun here, however, by the Newport News Ship Building & Dry Dock Company, which will have, when completed, one of the largest ship-building plants in the country. A large amount of work has already been done here, and is now approaching completion. The buildings include smith shops, machine shops, plate shops, etc., and are of large size and substantially constructed of brick. A few of the tools are already in place, including eight steam hammers in the smith shop, while other tools are being received and are under construction. The steam hammers are all of Bement, Miles & Company's make, and many of the machine tools are from the same establishment. The ship yard will have eight building slips, and there is already completed a Simpson dry-dock, which is similar in plan and construction to that at the Norfolk Navy Yard, described in another column, but is larger in size, being 600 ft. long, or 100 ft. longer than that at the Navy Yard. A commencement has already been made, and two iron tugboats are under construction. The first important work, which will be begun as soon as the shops are ready, will be the building of two large steamers for the New York and New Orleans trade. These steamers will be named *El Norte* and *El Sud*, and will be sister ships, 400 ft. long, 48 ft. beam and 33 ft. depth of hold. They will be equipped with quadruple-expansion engines of large size which will be built in the shops.

A GERMAN PASSENGER STATION.

THE accompanying illustrations, from the *Deutsche Bauzeitung*, show the new passenger station in Bremen, Germany. The building faces the principal park of the city, and the general design is very graceful, harmonizing well with the surroundings. The waiting-rooms and offices are in the building at the side, while the train-house is covered by a lofty arched roof, so designed as to form an integral part of the structure. Through this train-house there pass six tracks, belonging to the lines to and from Hamburg, Osnabrück, Geestemunde, Hanover and Oldenburg.

In addition to the platform close to the office building, there are two wide platforms running the length of the train-house. These are reached by tunnels running under the tracks, but on a level with the floor of the main waiting-room, the tracks being above the street level. The platforms are reached by stairways from the tunnels.

In the ground plan, fig. 2, the six tracks and the platforms are shown, and also an additional switching track,

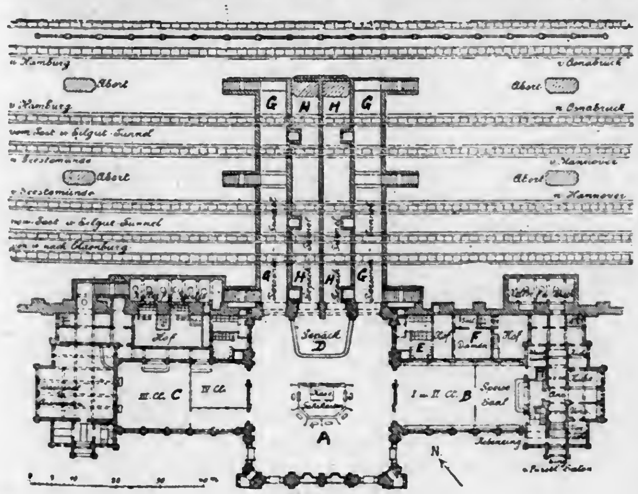


Fig. 2.

running outside the wall of the train-house. In this plan *A* is the main waiting-room ; *B*, the restaurant ; *C*, the third-class waiting-room ; *D*, the baggage-room ; *E* and *F*, the toilet-rooms ; *G G* are the tunnels or passages for passengers, and *H H* those for baggage.

The train-house is 646 ft. long, 194 ft. wide and 98 ft. high in the center. The roof is carried on iron arch girders.

The principal feature in the station building proper is the main hall or waiting-room, which is 105×120 ft. in size, and 78 ft. high to the center of the arched roof. A small view of the interior of this fine hall is shown in fig. 3. The ticket office detracts somewhat from the size of this hall, and the exit doors are rather too low in proportion ; but the general effect is very fine.

The central pavilion and its adjoining structure on each side have no second story. The wings have each three, the upper floors being used for offices and other necessary purposes. In one of them is the royal room, with which all first-class stations in Germany must be provided, and which is very handsomely fitted up and furnished.

THE NEW PASSENGER STATION AT BREMEN GERMANY.

The main building is of Obenkirchen sandstone, with trimmings of darker stone. The roof is surmounted in front by a parapet of cut stone ; the angles of the wings and the two half-towers which complete the front of the main pavilion are ornamented by groups of statuary. A small bell tower is placed in the angle between the east wing and the train-house, and carries a clock.

The arched roofs are covered with galvanized iron. The roofs over the restaurant and third-class waiting-rooms are chiefly of glass.

Fig. 3.

The station is well provided with all necessary conveniences, arranged, as is customary in Germany, separately for the different classes of passengers.

The architect of the building, who had charge of its designing and general construction, was Professor Hubert Stier, of Hanover.

AERIAL NAVIGATION.

By O. Chanute, C.E., of Chicago.

(A lecture to the students of Sibley College, Cornell University; delivered May 2, 1890.)

(*Continued from page 397.*)

PART II.—AVIATION.

Having sketched what has thus far been accomplished with, and what may be fairly expected from navigable balloons, we may next turn our attention to that other class of students who call themselves "Aviators," and who, discarding the use of a gas-bag, seek to solve the problem of flight by purely mechanical means. They point to the birds in confirmation of their views, and constitute by far the most numerous as well as the most ancient school; for, to say nothing of ancient traditions, earnest proposals have been brought forward during the last 400 years to compass flight by various mechanical contrivances.

With these students, the possibility of success has been more a matter of faith, of instinctive belief, than of sober calculation. They watched the birds, saw that they progressed through the air by mechanical action and skill, and were very much heavier, bulk for bulk, than the air which their bodies displaced (for we may dismiss with a smile the old-time assertion that birds gain levity by inflating their quills with heated air), and they hoped that man might accomplish similar results by somewhat similar means.

Impressed with these views, a number of these students have organized aeronautical societies in Great Britain, in France, and in Germany, and have for the past 20 odd years been reading papers, discussing the subject, and trying sundry experiments.

Very little practically has thus far come from these efforts, for curiously enough, and yet naturally, the first endeavors were to devise or to construct models, which have remained toys, before knowing accurately the resistances and conditions which they were to encounter in the air. In other words, the work began upon the constructive instead of the analytical features of the case, as usually happens at the outset of an invention, and while a good deal of valuable information has been gathered, no practical machine has yet resulted. Some theoretical investigations have been attempted, but unfortunately the scientists have been hopelessly at variance not only among themselves, but also, what is more important, with some of the ascertained facts.

Thus it has been so far unknown what power birds expend in overcoming the resistance of the air in their flight, or what amount of support they derive from it at various angles; and although the laws of fluid resistances laid down by Newton are known to be erroneous, they are still taught in the academies; and it was only the past summer that a new theory of flight, which may prove to be the correct one, was proposed simultaneously by two civil engineers at the Aeronautical Congress of the Paris Exposition.

Even the theory of the equilibrium of the common kite, supposed to have been invented by Archytas 400 years B.C., is still a subject of dispute, and every little while a fresh solution of its numerical reactions is proposed by a mathematician.

Possibly, in consequence of this state of uncertainty as to the laws of flight, the Aviators have been divided into three camps or sub-schools, which have looked for success from somewhat different contrivances, and who have advocated the following mechanical means:

1. The imitation of the flapping action of the wings of birds.
2. The sustaining of weight and obtaining progress simultaneously through the air by horizontal screws.
3. The sustaining of weight by fixed aeroplanes, and the obtaining progress by means of screws.

A great many experiments have been tried and a great deal of ingenuity has been expended in each of these three directions, but thus far not a machine has been able to leave the ground with its prime motor, and what measure of success has been attained can only be exhibited through toys, which give an idea of the principles involved.

The advocates of wing action hold that nature cannot err in her methods, and that success is only to be achieved by imitating her; they have therefore endeavored to devise moving surfaces which shall repeat the complicated movements of the wings of birds, so as simultaneously to sustain and propel the apparatus. The only motive power which it has thus far been found practicable to use has been the torsion of india-rubber, and with this a number of clever mechanical birds have been contrived by Mr. Brearey in England, and by MM. Penaud, Tatin, de Villeneuve and Pichancourt in France.

The latter—that of Pichancourt—dates only from last summer, and is represented by fig. 5.

It measures about 12 in. from tip to tip of wings, and weighs 385 grains, one-third of which consists in the twisted rubber strings furnishing the motive power. The necessary flexion of the wings, to obtain a propelling as well as a sustaining reaction, is produced by a triple eccentric, each actuating a lever fastened to a different point in the wings.

Fig. 5.

Upon being wound up and released, the apparatus flies slightly upward, and to a distance of 30 to 60 ft., in from 3 to 6 seconds. Similar but larger birds, of the same make, are said to have flown up to a height of 25 ft. and a distance of 70 ft. against a slightly adverse wind.

The relative power absorbed, however, is quite beyond the capacity of any known prime motor.

The next principle—that of an aerial screw to sustain and to propel simultaneously by its horizontal revolution—was actively promoted in France some 25 years ago, and great results were expected. It was proved, however, that it required about 1 H.P. to sustain 33 lbs. in the air, or much more than the energy of any engine, and the sole survivors of the many experiments made are the various flying screws which still amuse children; the best of these being that of Penaud, shown in fig. 6, in which two screws rotate in opposite directions and cause the apparatus to rise or to fly in a circle, according to the proportions of its various parts.

And lastly, in recent years, experiments have been made with combinations of fixed surfaces, called aeroplanes, to sustain the weight, and of rotating vertical screws to propel. Machines or models on this principle have been built by Heuson, Stringfellow and Moy in Great Britain, and by Penaud, Tatin, de Louvrié, and du Temple in

France, but thus far not one has succeeded in lifting a self-contained motor, and perhaps, after all, the best example of this class of contrivance is the artificial butterfly of M. Daudrieux, which is shown in fig. 7.

The flight of all these toys lasts but a few seconds, and

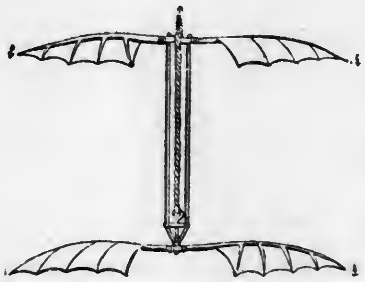


Fig. 6.

none of them carries its own motive power, while it will be found by measuring accurately the foot-pounds expended, and the weights sustained in a given time, that not one of the prime movers known is as yet sufficiently light, in proportion to its energy, to furnish the power required to maintain them in the air.

This question of motive power, the vital one in Aerial Navigation, will be discussed more particularly hereafter, but it may here be mentioned that a few observers, who have been watching birds soar without flapping their wings in southern latitudes, believe that this species of flight involves no expenditure of power whatever, save for the getting under way. This opinion has been much ridiculed, but yet it is possible that if we take into account the force of the wind, the belief of these observers that certain birds can soar indefinitely at moderate speeds without other exertion than the passive one of keeping the wings rigidly extended may not be as absurd as at first sight appears ; but if man is ever to direct himself at will through the air, at satisfactory velocities, he will need power, and plenty of it ; more indeed in proportion to the weight of the motor and of its supplies than he has yet been able to devise.

Meanwhile a few observers and scientists have been patiently investigating the motions which birds perform

Fig. 7.

in their flight. Among these may be mentioned the Duke of Argyle and his book, "The Reign of Law ;" M. Mouillard and his "Empire de l'Air ;" Dr. Petigrew and his book on "Animal Locomotion," and especially Professor Marey, who has just published a book, "Le Vol des Oiseaux," the result of 20 years' investigation, which is most interesting and valuable, but which, unfortunately, throws but little light upon the all-important questions as to the sustaining reactions to be derived from the air, and the power required for flight ; the latter having remained in controversy since the days when Navier made the erroneous calculation that a flying swallow exerted one-seventeenth of a H.P., or at the rate of no less than 3,586 H.P. per ton of weight.

Of course, the first thing to ascertain is to know what are the components of air pressure upon a plane in motion at a given velocity, if inclined to the current. In other words, what proportion of the usual right angle pressure remains if the plane be tilted, and how much of this new pressure acts as a sustaining force or *lift*, while how much opposes forward progress, and may be denominated *drift*. Some interesting experiments have been made in Great Britain on this subject, and more of them in France, but they have chiefly been made with some form of rotating apparatus, and it was found not only that the results obtained with direct currents did not agree with those of rotary machines, but that the latter showed greater pressures on planes inclined at angles of 50° to 70° than on those placed at right angles to the current (a most improbable condition), so that it is now believed that the centrifugal force of the rotating vanes in some way vitiates the results, and the French have been preparing to try a new set of experiments upon artificial currents to be produced by large ventilating fans.

Things were in this condition when an International Congress of Aeronauts and Aviators was held in Paris last August. During this a number of papers were presented, and among them were two which may lead hereafter to a new and more rational theory of flight. One was by a Russian engineer, M. Drzwieki, who, starting from the best empirical formulæ he could find, had calculated the weights sustained, the surfaces required, and the power needed for aeroplanes in artificial flight at various velocities, while the second paper was a theoretical investigation of the same subject by the present lecturer.

The remarkable result about these papers was that, starting from two different standpoints—the empirical and the theoretical—they closely agreed in their conclusions ; and as the paper of M. Drzwieki was the most complete and thoroughly worked out, I shall prefer to give an account of it rather than of my own.

M. Drzwieki first showed that the hitherto received idea that a bird in flapping his wings generated thereby a sufficient pressure to sustain his weight is incorrect. It has long been known that the pressures experimentally obtained by striking the air with surfaces of equal area and velocity with those of the wings of a bird, or even with the wings of a dead bird dried and mounted in an apparatus, do not generate a sustaining reaction equal to the weight of the bird ; but it was dimly believed that the living bird had the skill, in some mysterious way, of obtaining from his strokes sufficient intensity of pressure to sustain his weight. M. Drzwieki says that this view is quite erroneous, and that the bird is really sustained by the vertical component of the pressure due to his speed. In other words, that the flying animal is really an aeroplane, whose body and wings in all stages of their action make a very small angle with the impinging air, and that the propelling power is chiefly derived from the rear thrust exerted by the escaping air against the outer curved extremity of the quill feathers.

Moreover, if account be taken of the forward motion, the angle which the wings present to the line of flight must be less than 6°. It is imposssible to detect this angle of incidence by the eye. The wing seems to be flapped vertically downward ; or in soaring the bird seems to hold his wings and body absolutely horizontal ; but in point of fact we know that there must be an angle of incidence in order to obtain a sustaining reaction. This brings up the inquiry as to what that angle really is.

M. Drzwieki starts from Duchemin's empirical formula of the normal resistance which air opposes to an inclined plane moving against it, and deduces therefrom the sustaining reactions per square meter at various velocities for various angles from 20′ to 10°, and these are tabulated for ready reference. Next he calculates the horizontal components of the normal pressure for the same velocities and angles, this being the resistance to the advancement of the plane alone, and to this is added the head resistance due to the thickness necessary to secure the required

strength of the plane, or, in other words, its hull resistance, and to this again is added the probable friction of the air against the sides. These three items together give the total resistance to forward motion, and are also tabulated for ready reference.

Then, by combining these two tables and plotting the resulting curves, in order to ascertain at what angle there is a minimum of resistance to forward motion, while yet retaining a sufficiency of sustaining power, it is found that this occurs for one and the same angle at all velocities, this being 1° 50′ 45,″ and this M. Drzwieki assumes as the angle of flight.

I may here mention that these two reactions, or components of the normal pressure due to the angle of incidence and to the speed, formed the subject of the paper read by myself at the Paris Congress, and of a similar paper which I presented before the American Association for the Advancement of Science at its last meeting, and that I had reached the conclusion that the most favorable angle for soaring was between 1° and 2°.

Assuming 1° 50′ 45″ as the angle of flight, and allowing for the vertical and horizontal components of the normal pressure due to the speed at that angle, as well as for the hull resistance and friction, M. Drzwieki then gives four formulæ, supplemented by tables, which produce the following elements:

1. The weights per square meter, which can be sustained at this angle of 1° 50′ 45″ at various speeds.

2. The work done (kilogrammeters) to overcome the forward resistances under the same circumstances as above.

3. The proportion of the work done to the weight sustained.

4. The amount of surface required to sustain 1 kilogramme at various velocities.

The consequences which M. Drzwieki deduces from these formulæ and the plotting of their curves are the following:

1. An aeroplane progressing horizontally, with the angle of incidence (1° 50′ 45″) corresponding with the minimum of work, meets practically the same resistance at all speeds, so that the work done is approximately a function of the weight of the apparatus, multiplied by the velocity.

2. Aeroplanes designed for small speeds need relatively large surfaces and small weight; these conditions he believes to be difficult of realization in practice.

3. The greater the speed, the less surface needed to support a given weight.

4. The less the surface, and therefore the greater need of speed, the greater must be the motive power.

These conclusions are believed to be approximately sound, and M. Drzwieki sustains them by showing that in flying birds the smaller is the sustaining surface in proportion to their weight, the greater is their customary speed, giving a table of the proportions of some 64 birds, which shows that the surfaces of the body and extended wings range from 7.56 sq. ft. to the pound for the bat, which flies at the rate of about 20 miles per hour, to 0.43 sq. ft. per pound for the male duck, who progresses at about 60 miles per hour. He estimates that for a speed of 90 miles per hour, the surface required will be but 0.22 sq. ft. to sustain a pound of weight.

It seems to follow as a conclusion that if aeroplanes are ever built to carry tons of weight, their proportion of surface to weight may be considerably less than those which obtain with birds, but that the speed will need to be greater than that of flying animals in order to obtain support from the air, while the motive power required will vary approximately only in the direct proportion of the weight carried. This important conclusion seems to hold out hopes that success may eventually be attained if the stability of the apparatus can be secured.

M. Drzwieki also discusses this question of stability. He shows that the transverse equilibrium can easily be maintained by a diedral upward slant of the wings of an aeroplane, arranging them like the sides of the letter V, but at a very obtuse angle, so that any tendency to tilt shall at once develop greater pressure in that direction, and thus restore equilibrium. This was pointed out as early as 1809 by Sir George Cayley, in a remarkable series of papers published in *Nicholson's Journal*, which are well worth reading.

M. Drzwieki states the law of longitudinal equilibrium to consist in placing the center of gravity of the whole apparatus vertically below the center of pressure due to the angle of flight, and he gives the rule, first formulated by Joëssel, for determining this center of pressure. He moreover states that these two centers, of gravity and of pressure, must be but a very short distance apart, in order to prevent oscillations. This solution is substantially, for flat angles of incidence, the same as that of Sir George Cayley, who states that the center of gravity must be at right angles to and below the center of pressure; but it is to me doubtful whether this is the best solution for assuring the longitudinal stability of a flying apparatus, and this important, almost vital question is likely to prove a stumbling-block in the way of future experimenters.

Assuming it to be solved, M. Drzwieki estimates that an apparatus, built to the best possible proportions as to exposed surface and form, and sailing at an angle of 1° 50′ 45″, will require to drive it at 25 miles per hour but 5.87 H.P. per ton of its weight. This assumes the thickness of apparatus and consequent hull resistance to be but $\frac{1}{100}$ of its horizontal dimensions, while for birds it generally runs from 5 to 10 per cent. That is to say, that birds exposing a horizontal surface of say 100 sq. in. generally expose a maximum cross-section vertically of 5 to 10 sq. in., while M. Drzwieki believes this can be reduced to the proportion of 1 sq. in. per hundred for an aeroplane.

My own estimate of the power required by a common pigeon gliding at an angle of 1° with the horizon was 9.33 H.P. per ton of his weight, and 10.49 H.P. per ton at an angle of 2° for this same velocity of 25 miles per hour.

These are considerably less than the powers required to drive a balloon of moderate size at the same speed, for we have already seen that the air-ship *La France* would require 51 H.P. to attain 25 miles per hour; or, as it weighs 2.2 tons, the motor would needs develop 23.2 H.P. per ton of the weight of the whole apparatus. For the balloon of double this size, the power required is at the rate of 10.34 H.P. per ton of apparatus. This power required would moreover increase in the case of the balloon, as the cube of the velocity, while M. Drzwieki shows that in the case of an aeroplane the power will increase only in the direct ratio of the speed, because as the velocity becomes greater the area of sustaining surfaces required becomes less, and he estimates that an aeroplane will require 10.43 H.P. per ton to go 44.72 miles per hour, and 20.62 H.P. per ton of its weight at 89.44 miles per hour.

(TO BE CONTINUED.)

ELECTRIC TRANSMISSION OF POWER.

(Condensed from *Le Genie Civil.*)

DURING the year just closed the paper-mill at Moutier, in the Department of l'Isere, has been the scene of an important series of transformations, the object of which was to replace the existing motive power by electric transmission. This was partly favored by circumstances, and has been a complete success. To describe properly the plan, it will be necessary to give some little description of the neighborhood.

The village of Moutier is situated about 500 m. (1,640 ft.) from Domene, and 11 km. (6.84 miles) from Grenoble. The track of the railroad line from Chambery to Valence, which runs the whole length of the Gresivauban Valley, passes close to the factory, not far from the station of Domene.

Below Moutier the river Isere receives the waters of a small stream called the Domenon, which issues from a mountain which overlooks the peak of Bellebonne, at a height of 2,980 m. (9,774.4 ft.) above the sea level. If we follow this stream from its mouth above the village of

Domene, we enter a narrow gorge, the rocky walls of which rise at different points 200 m. (656 ft.) above the current. On the banks of this stream stand some paper-mills which are run by water power, the power being derived from a fall 180 m. (590.4 ft.) in height at some distance above, from which it is necessary to carry the water about 2 km. through a canal to reach the turbine wheels.

Above this gorge, and close to the stream, there is a little hamlet, known as Eaux-de-Revel, which is 5 km. from Domene by the course of the stream. This is at the foot of a fall which has been used for motive power, and at this point have been established the turbine wheels and the generating dynamo which transforms water power into electric energy. Above this point the Domenon, for a considerable distance, has an average fall of 1 in 10, and at the bridge of Cornets, where the water is taken, the level is 70 m. (229.6 ft.) above the power-house, to which it is conveyed by a wrought-iron pipe having a total length of 700 m. (2,296 ft.). It was necessary to give this pipe a foundation sufficiently solid to prevent it from being disturbed by the frequent floods. The present arrangement is only temporary, and when more power is needed water will be taken from a point which will give a total fall of 130 m. (426.4 ft.) to the power-house. Above this point there are two small hamlets and several houses, and upon the right bank there comes in an important tributary stream, the Dhuys, which is fed by a considerable rocky water-shed, and which brings to the Domenon a supply without which the water in winter would be too low to supply the necessary power. A little further up, upon the opposite bank, there is also a small stream which flows from Lake Robert, and which is fed somewhat irregularly

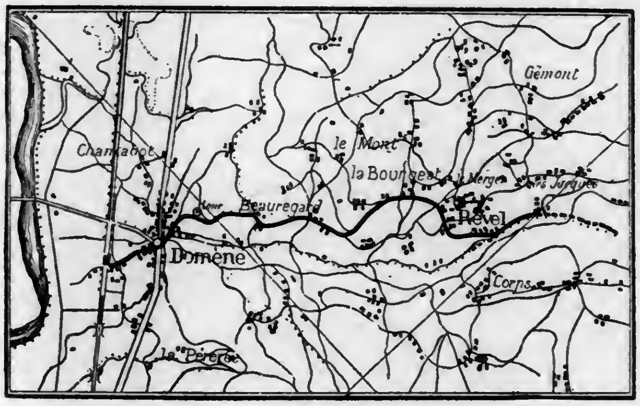


Fig. 1.

by the melting snows from the Petite Bodene. Above this point the mountain rises abruptly, and there are several small falls ending in the Cascade of l'Oursiere, where at a single leap the stream falls 60 m. (196.8 ft.), and in the spring the flow of the stream is from 13 to 15 cubic meters (458 to 530 cub ft.) per second. Above this cascade the forest ceases and the mountain is rocky and desolate ; and here are found the sources of the stream in several little lakes where are gathered the waters derived from the melting of the snows, and of a glacier which is found on the southwestern slope of the mountain.

At the power-house, which has been named "La Force," the generating dynamo, which is driven by a turbine with a horizontal shaft, is joined by two wires carried on poles, which convey the power to the receiver at Moutier from La Force. The line runs directly out some distance from the stream to the village of Revel, whence it follows the road well known to tourists who ascend the mountain. The posts are set at the side of the road until they reach the gorge before referred to, when they leave the road and descend almost in a direct line with an inclination averaging 60°, thus avoiding the numerous windings of the road.

The general conditions of the working of this transmission are as follows : The generating dynamo has a maximum speed of 240 revolutions per minute and a maximum power of 300 H.P. The receiver has a maximum speed of 300 revolutions per minute and a maximum power of 200 H.P. The transmitting line is 5 km. (3.11 miles) in length. The electro-motive power has a maximum of 2,850 volts and a maximum intensity of 70 ampères. The electric result obtained, calculated after deducting all re-

Fig. 2.

sistances, is 83 per cent. of the total power, while the average mechanical result is 65 per cent.

Since it has been put in operation this transmission has run steadily day and night. Although the running of the machinery does not present any special difficulty, it is worthy of note that it is managed entirely by the same persons who formerly ran the machinery with steam power, but who, although they had no previous acquaintance with the management of dynamos or electric motors, have had no difficulty in operating these.

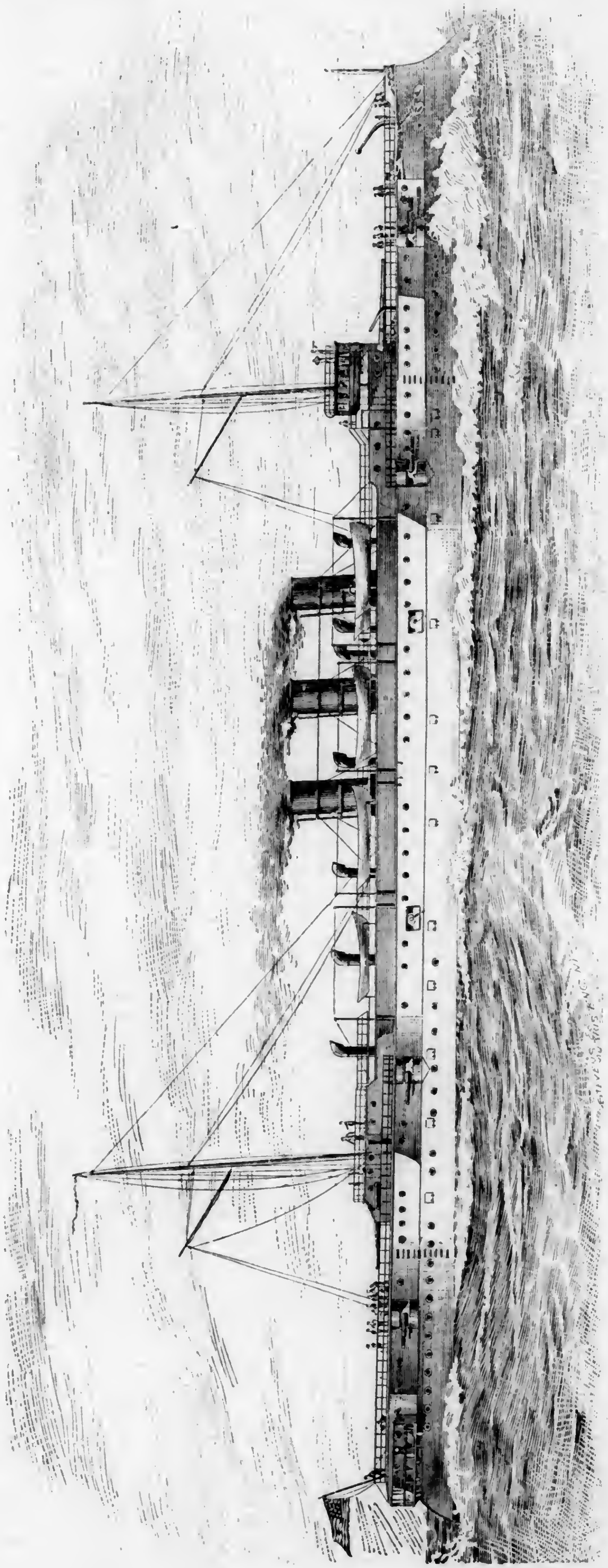
This installation was made by M. Hillairet, who designed it, and who deserves much credit for its completeness and the excellence of its arrangement.

In the accompanying illustrations, fig. 1 is a small map showing the location of the transmission ; fig. 2 shows a part of the pipe through which the water is conveyed to

Fig. 3.

the turbine, and fig. 3 is a view of the power-house at La Force.

If this plan for transmission of power had not been adopted, it would have been necessary to use steam power for the paper-mill, since at the point at which the water could be used there was no place at which mills of any size could be erected, owing to the rugged nature of the



CRUISER NO. 12 FOR THE UNITED STATES NAVY.

ground; and moreover it would have been impossible to convey material to or from the mills, should they be located there, or to build roads over which heavy loads could be hauled. The power was there, but could be made available only by this method of transmission. When this installation was completed and put in operation, the first cold weather was just beginning, and the snow and ice in a short time made the road from Domene to Revel impassable for any description of vehicles. From the end of November to the middle of March this continued, so that for over four months hardly the smallest load could be carried up to La Force. In spite of this, however, the working was never stopped, nor did the snow or the ice effect the line of transmission. The same result followed during the spring storms, when also there was no interruption whatever to the work. It is only necessary to supply the men in charge of the dynamos with provisions, with oil for lubrication, etc. The station is united with the mill by a telephone line carried on the same posts as the line of transmission, and communication is consequently maintained.

Four persons are especially employed on the electric work, two having charge of the generating dynamo at La Force and two of the receiver at the mill. One is constantly on duty at each end, the men taking their turns at day and night service. The conductor at the receiver is under the direct orders of the man who is running the dynamo, and performs the same functions as an engineer in an ordinary mill. In this case the two employés who hold the position at the receiver are the two old engineers of the mill.

THE NEW FAST CRUISER.

THE accompanying illustration, which is prepared from a photograph furnished by the Navy Department, shows the design adopted for the new swift cruiser of 7,300 tons displacement—the largest cruiser yet designed for the Navy—officially designated as Cruiser No. 12.

The building of this vessel was authorized by the Navy appropriation bill of 1890, and proposals for building it have been invited. The description given below embodies substantially the specifications issued by the Navy Department.

Bids will be received for constructing ship and engines in accordance with the plans prepared by the Department, or on plans to be furnished by bidders. In the latter case, however, the plans submitted must conform to certain requirements, which are substantially as follows: All parts and material must be of domestic manufacture, and in compliance with the provisions of the act of August 3, 1886. The contractor must guarantee an average speed in the open sea, under conditions prescribed by the Navy Department, of 21 knots per hour, maintained for 4 consecutive hours, during which period the air pressure in the fire-rooms shall not exceed 1 in. of water, and for every quarter-knot of speed so developed above said guarantee, the contractor shall receive a premium over and above the contract price of $50,000, and for every quarter-knot that the vessel fails of reaching the required speed, there shall be deducted from the contract price the sum of $25,000.

The vessel must be completed within $2\frac{1}{2}$ years after the contract is signed.

The Department plans call for a vessel 400 ft. long on the mean load line; beam, moulded, 58 ft.; draft, mean normal, 23 ft.; extreme normal, 24 ft. Displacement, normal, about 7,300 tons; speed, sustained, 21 knots; and indicated H.P., 20,500.

The main battery consists of four 6-in. breech-loading rifles, of high power; eight 4-in. breech-loading rifles, rapid firing; about 18 machine guns, and 6 torpedo tubes.

The arrangement of the motive power will be somewhat novel, as the force will be transmitted through three screws: one placed amidships, as in ordinary single-screw vessels, and two others placed further forward, one on each side, as is usual in twin-screw vessels; this arrangement is not entirely new, having been adopted by the French for some of their later vessels, but represents the latest advance in the steam engineering line where such great power is to be transmitted. If twin screws were used, over 10,000 H.P. would pass through one shaft; now each shaft transmits only 6,850 H.P., and the vessel has one more chance in case of break-down.

The machinery and boilers were designed by Engineer-in-Chief George W. Melville, U. S. N., Chief of Bureau of Steam Engineering, and consists of three sets of triple-expansion, vertical, inverted cylinder engines, driving the triple screws before mentioned. The center screw is about 4 ft. 6 in. below the other two.

Fig. 2 is a plan showing the arrangement of the three screws. Fig. 3 is a rear view, on a somewhat larger scale, showing also the position of the screws. The side screws are three-bladed and are each 13 ft. 9 in. in diameter; the middle screw is four-bladed, and is 12 ft. in diameter. The middle screw is 4 ft. 6 in. lower than the side screws, and 15 ft. farther aft. It will have a somewhat coarser pitch than the side screws. The centers of the side screws will be immersed about 12 ft. at ordinary load draft.

Each engine is placed in a water-tight compartment, and is complete in every respect, so that the vessel may be propelled at a slow speed by the center screw alone; by the two outer screws at a medium speed; and by the three screws when the highest rate of speed is required. Each shaft is fitted with a disengaging coupling, so that when not in use the propellers are free to revolve.

The great advantage of this arrangement is that it allows the machinery to be worked at its maximum and most economical number of revolutions at all rates of the vessel's speed; and each engine can always be used for propelling the vessel, an advantage of great importance, and one that the arrangement of two sets of engines working on the same screw does not possess.

The steam pressure is 160 lbs. The diameter of high-pressure cylinder is 42 in.; of intermediate pressure cylinder, 59 in.; of low-pressure cylinder, 92 in.; stroke, 42 in.

The shafting is made of forged steel 16.5 in. in diameter, with an axial hole 7.5 in. in diameter. Steel has been used wherever possible, so as to make the machinery as light as is consistent with safety.

The total capacity of the circulating pumps per minute when used for bilge purposes is 40,500 gallons.

The total indicated power at 129 revolutions per minute and a forced draft of 1 in. of water is 21,000 H.P.

There are eight main double-ended boilers, placed in four water-tight compartments, and two single-ended, auxiliary boilers placed on the berth deck. The air-tight fire-room system of forced draft is used.

Six of the double-ended boilers are 15 ft. 6 in. in diameter and 21 ft. 6 in. long, each having 8 furnaces and 175.5 sq. ft. of grate surface, and 5,952.4 sq. ft. of heating surface.

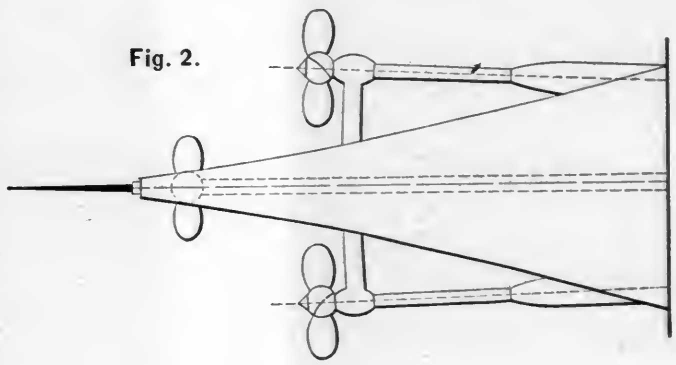
Two of the double-ended boilers are 11 ft. 8 in. in diameter and 18 ft. 8.5 in. long, each having four furnaces and 84 sq. ft. of grate surface and 2,870 sq. ft. of heating surface. The total grate surface for the main boilers is 1,221 sq. ft.; the total heating surface for the main boilers is 41,334.4 sq. ft.

Each auxiliary boiler is 10 ft. in diameter and 8 ft. 6 in. long, with two furnaces, and has 32 sq. ft. of grate surface and 968.5 sq. ft. of heating surface. The total grate surface for auxiliary boilers is 64 sq. ft.; the total heating surface is 1,937 sq. ft.

All the boilers are constructed of steel for a working pressure of 160 lbs.

The vital portions of the vessel are protected by an armored deck 4 in. thick on slopes and $2\frac{1}{2}$ in. on the flat; the space between this deck and the gun-deck will be minutely subdivided by coal bunkers and store-rooms; in addition to these a coffer-dam 5 ft. in width will be worked next to the ship's side for the whole length of the vessel. In the bunkers this will be filled with patent fuel, forming a wall 5 ft. thick against machine-gun fire; the contents can also be utilized as fuel in an emergency. Forward and aft the coal bunkers, the coffer-dam will be filled with some water-excluding substance similar to woodite.

Fig. 2.



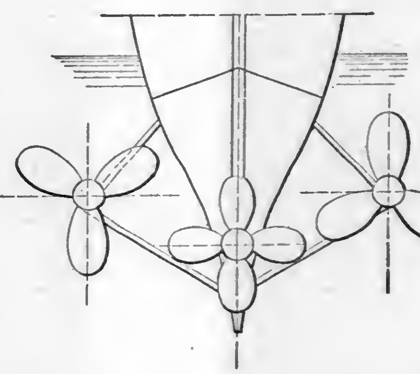


Fig. 3.

In wake of the 4-in. and the machine guns the ship's side will be armored with 4-in. and 2-in. plates.

The 6-in. guns are mounted in the open, protected by heavy shields attached to the gun carriages.

The accommodations for officers and crew are spacious, well ventilated and lighted. All the most approved modern appliances for exhausting vitiated air and for incandescent lighting by electricity have been incorporated in the design.

The coal capacity is very large, reaching 2,000 tons; at 10 knots' speed per hour this will give the vessel an endurance of 109 days, or a radius of action of 26,240 knots; in other words, she will be able to steam around the world in 109 days without recoaling.

In appearance the vessel resembles closely an ordinary merchantman, the sides being nearly clear of projections or sponsons, which ordinarily appear on vessels of war; she will have two signal masts, which will have no military tops on them, however.

The function of the vessel is to destroy the commerce of an enemy; therefore, her general appearance is such as to enable her to get within range before her character is discovered.

As a whole, this vessel will represent the latest idea of a powerful, economical, protected commerce destroyer.

The hull will be of steel; the vitals of the ship and its stability well protected, and the gun-stations shielded against machine-guns.

The subdivision of the hull is such as to form a double hull below the water, and offers as great security against damage from torpedo attack as can be given in a vessel of this class.

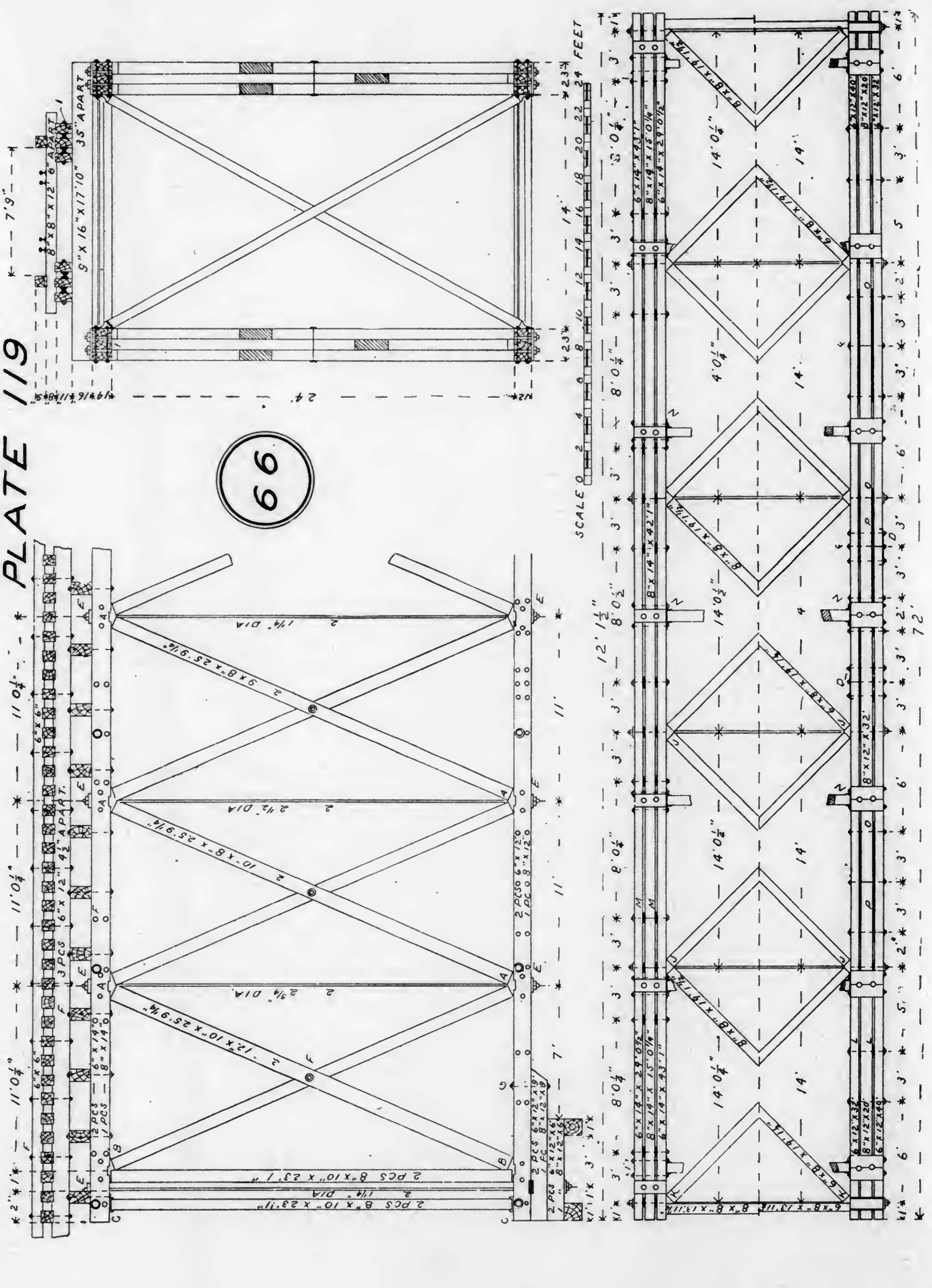


PLATE 119
66
SCALE
FEET

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C.E.

(*Continued from page* 400.)

CHAPTER XXVIII.

HOWE TRUSS BRIDGES.

Plates 119, 120 and 121 show a design for a Howe truss deck bridge of 66 ft. span. Plate 119 shows the general design, while the details will be found in plates 120 and 121.

The bill of materials given herewith will, with the plates, give all that is necessary to understand fully the construction of the bridge.

No. 48. Bill of Material for Howe Truss Bridge. Deck Span, 66 Ft. Plates 119, 120 and 121.

Timber.

No. of Pieces.	Description.	Size.	Length.	Ft. Board M's're.	Kind of Wood.
4	Top Chord......	6 in. × 14 in.	43 ft. 1 in.	1,207	Yellow Pine.
4	" "	6 in. × 14 in.	29 ft. 1½ in.	816	" "
4	" "	8 in. × 14 in.	15 ft. 0¼ in.	564	" "
2	" "	8 in. × 14 in.	42 ft. 1 in.	786	" "
4	Bottom Chord..	6 in. × 12 in.	40 ft. 0 in.	960	" "
4	" " ..	6 in. × 12 in.	32 ft. 0 in.	768	" "
4	" " ..	8 in. × 12 in.	20 ft. 0 in.	640	" "
2	" " ..	8 in. × 12 in.	32 ft. 0 in.	512	" "
8	Braces	12 in. × 8 in.	25 ft. 9¼ in.	2,064	" "
8	"	10 in. × 8 in	25 ft. 9¼ in.	1,384	" "
8	"	9 in. × 8 in.	25 ft. 9¼ in.	1,240	" "
12	Counters.......	9 in. × 7 in.	25 ft. 9¼ in.	1,320	" "
16	End Posts.....	8 in. × 10 in.	23 ft. 11 in.	2,560	" "
10	Laterals........	6 in. × 8 in.	19 ft. 1½ in.	770	" "
10	"	8 in. × 8 in.	19 ft. 1½ in.	1,020	" "
2	"	6 in. × 8 in.	13 ft. 11¼ in.	112	" "
2	"	8 in. × 8 in.	13 ft. 11¼ in.	150	" "
8	Bolsters........	6 in. × 12 in.	9 ft. 0 in.	432	" "
4	"	8 in. × 12 in.	9 ft. 0 in.	288	" "
8	Bridge-seats....	6 in. × 12 in.	6 ft. 0 in.	288	" "
4	" "	8 in. × 12 in.	6 ft. 0 in.	192	" "
4	Sills............	12 in. × 12 in.	18 ft. 0 in.	864	Spruce or Pine.
20	Floor-beams....	9 in. × 16 in.	18 ft. 0 in.	4,320	" " "
6	Stringers.......	6 in. × 12 in.	72 ft. 0 in.	2,592	" " "
62	Ties............	8 in. × 8 in.	12 ft. 0 in.	....	Oak.
2	Guards.........	6 in. × 6 in.	72 ft. 0 in.	532	Spruce or Pine.
4	Plank...........	2 in. × 8 in.	72 ft. 0 in.	384	" " "
8	Blocks........	2 in. × 8 in.	2 ft. 0 in.	24	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods... ...	2¾ in.	26 ft. 10 in.	12	Bolster b'lts	1¼ in.	2 ft. 4 in.
8	"	2½ in.	26 ft. 10 in.	12	" "	1¼ in.	3 ft. 4 in.
8	"	2½ in.	28 ft. 10 in.	20	Fl. beam b'ts	1¼ in.	4 ft. 4 in.
4	"	1¾ in.	26 ft. 10 in.	48	String'rb'lts	¾ in.	2 ft. 6 in.
8	Laterals....	1½ in.	18 ft. 6 in.	28	Tie-bolts.	¾ in.	2 ft. 6 in.
4	" ...	1¾ in.	18 ft. 6 in.	28	G'rd-r'l-b'lts	¾ in.	1 ft. 3 in.
192	Chord-bolts.	¾ in.	2 ft. 0½ in.	24	Spikes......	½ in.	9 in.
12	Brace-bolts.	¾ in.	2 ft. 0½ in.				

Other Iron Work.

Washers: 650 of pattern *F*; 88 of *G*; 24 of *H*.

Castings: 20 of pattern *A*; 8 of *B*; 4 of *C*; 4 of *D*; 28 of *E*; 36 of *I*; 16 of *J*; 8 of *K*; 72 of *L*; 64 of *M*; 28 of *N*; 24 of *O*; 6 of *P*; 12 of *Q*.

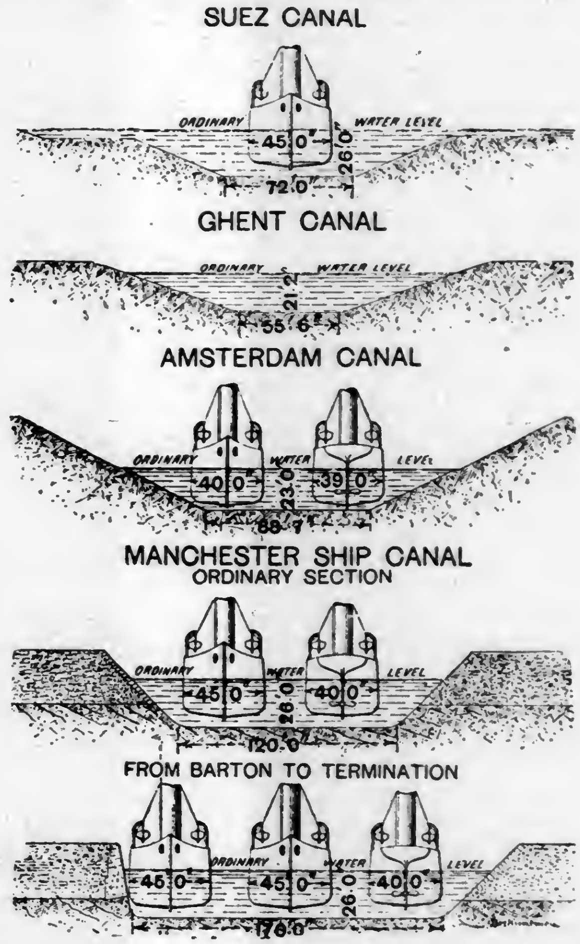
The kind of timber used may be changed when necessary, though that given is the best.

(To be continued.)

THE MANCHESTER SHIP CANAL.

Work on the Manchester Ship Canal, perhaps the greatest engineering work under construction in England, is now in progress on a large scale. It is intended to give access for large vessels to the great manufacturing city of Manchester, and the projectors believe that the saving effected by the delivery of raw materials and the loading of manufactured goods at the wharf in Manchester, avoiding the cost of trans-shipment and the railroad haul from Liverpool, will be a great benefit to the city.

The canal begins not far from Liverpool, at the village of Eastham, on the Cheshire side of the Mersey, and ends at Throstle Nest, Manchester, in a group of docks; it is about 35½ miles long, and has a minimum width at the bottom of 120 ft., with a minimum depth throughout of 26 ft.; compared with the Suez Canal, the depth is the same, but the width is 48 ft. greater. The cross sections of the various canals given in the accompanying cut show the



capabilities of the Manchester Ship Canal in comparison with those of others. The railroads over the canal will be carried by high-level bridges, and the roadways by swing bridges, the minimum clear height under the fixed railroad bridges being 75 ft. The water supply of the canal is to be derived from the Irwell, Mersey, Bollin, and other smaller streams; but, if necessary, pumping will be resorted to to make up the loss through lockage.

The line follows the south bank of the River Mersey for a considerable distance very closely. After leaving the river bank it still follows the valley of the Mersey to Irlam, whence it runs up that of a tributary, the Irwell, to Manchester.

There are five sets of locks, the first, at Eastham, being a tidal lock through which vessels pass from the river to the canal. The second lock is at Latchford, 20½ miles from Eastham, and has 16 ft. 6 in. lift; the third is at Irlam, 28 miles from Eastham and has 16 ft. lift; the fourth is at Barton 30½ miles from Eastham, and has 15 ft. lift; the fifth is at Mode Wheel, 33½ miles from Eastham, and has 13 ft. lift.

PLATE 120

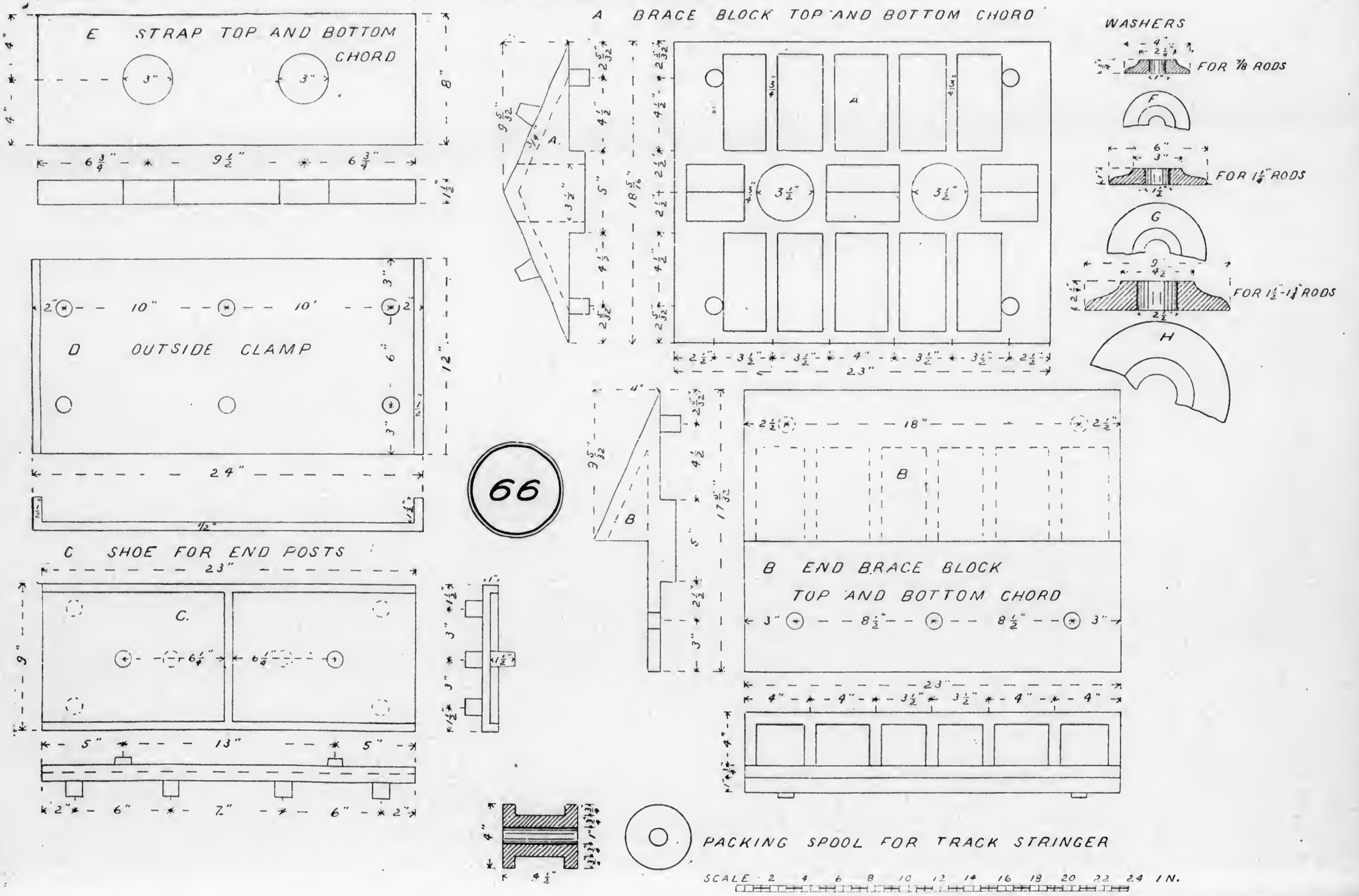
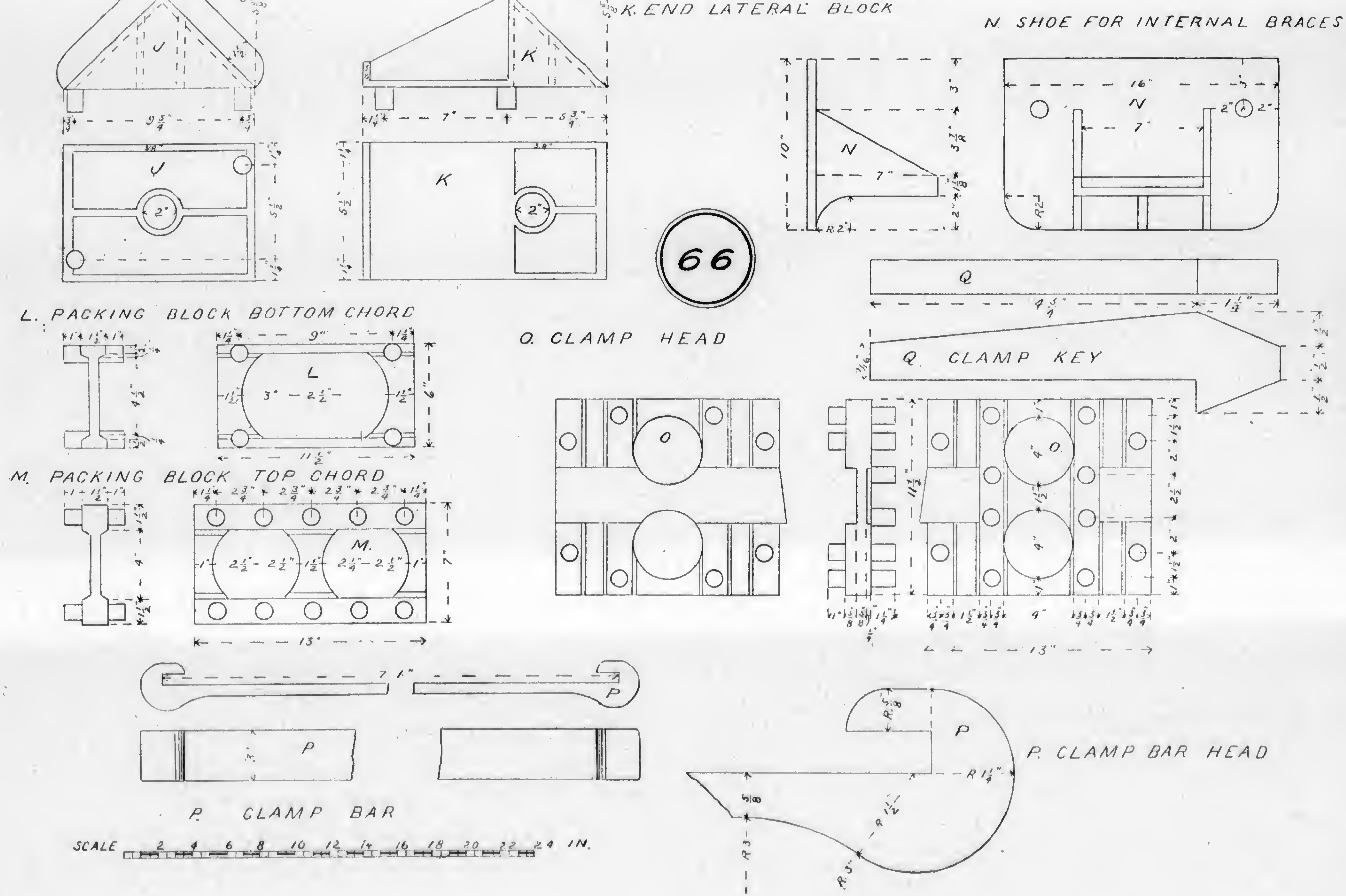

E STRAP TOP AND BOTTOM CHORD
A BRACE BLOCK TOP AND BOTTOM CHORD
WASHERS
FOR 7/8 RODS
F
FOR 1¼" RODS
G
FOR 1½"-1¾" RODS
H
D OUTSIDE CLAMP
66
B END BRACE BLOCK
TOP AND BOTTOM CHORD
C SHOE FOR END POSTS
PACKING SPOOL FOR TRACK STRINGER
SCALE 2 4 6 8 10 12 14 16 18 20 22 24 IN.

PLATE 121



J. LATERAL BLOCK TOP AND BOTTOM CHORD
K. END LATERAL BLOCK
N. SHOE FOR INTERNAL BRACES
66
L. PACKING BLOCK BOTTOM CHORD
O. CLAMP HEAD
Q. CLAMP KEY
M. PACKING BLOCK TOP CHORD
P. CLAMP BAR
P. CLAMP BAR HEAD
SCALE 2 4 6 8 10 12 14 16 18 20 22 24 IN.

The total lift is thus 60 ft. 6 in. The canal is divided into five levels, the length of which, respectively, is $20\frac{1}{2}$, $7\frac{1}{2}$, $2\frac{1}{2}$, 3 and 2 miles.

The width of the canal at the top varies, of course, with the slopes of the sides; these are made ranging from 1 in 6 through rock to 2 to 1 in clay and soft material. Except when passing through rock, the slopes are pitched with rough stone on a rubble backing to protect them from the wash of passing vessels.

The total amount of excavations in the canal is about $47\frac{1}{2}$ million cubic yards, one-sixth of which is in the rock. The walling of the various locks contains about 700,000 cubic yards of concrete, exclusive of brickwork and masonry; the walls of the Manchester and Salford Docks contain about 600,000 cubic yards of concrete. The weight of steel and ironwork in the fixed and swing bridges is about 15,000 tons.

The whole of the contract was let to the late Mr. T. A. Walker, who died in November last, and the work is now being carried on by his executors. The contract requires it to be completed by December 31, 1891.

The work is divided into nine sections, each under charge of a separate staff. A railroad and a telephone line have been built the whole distance from Eastham to Manchester.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

XII.–THE WORKING QUALITIES OF PAINT.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page* 417.)

In our analyses of the requisites of a good paint in the last article, one point which has usually been regarded as of very great importance in paints, was overlooked, or at least not mentioned, and this is what is technically known as "covering power." This was not wholly unintentional, as we have always been somewhat skeptical of the common explanation of what is known as "covering power." There is unquestionably a difference in different pigments, as we ordinarily use them, in their ability to hide a surface, but we are not yet fully satisfied as to whether this is an inherent difference in pigments, or is a difference of physical condition. It may possibly be both, but we will treat this subject more at length later.

Meanwhile, for the sake of having the subject clearly before us, we will say that the requisites of a good paint are, first, durability, which has already been discussed; second, that it shall work properly during its application; third, that it shall dry with sufficient rapidity, and fourth, that it shall have the proper covering power. This article will be more especially devoted to working qualities of paint.

Before beginning the discussion of the working qualities of a paint, however, perhaps a little further analysis is necessary. Painting may be divided, according to the use to which the paint is put, and especially according to whether it is expected to protect a surface or not, into two classes. The first of these classes is generally known under the head of "house painting," and covers the painting of all surfaces, where the paint itself is not only expected to give the appropriate color that is desired, but also to protect the surface against the weather. The other kind of painting is known as "coach painting," in which the color is the thing sought for, the protection of the surface, and also of the coloring material of the paint being secured principally by the varnish. These two kinds of painting are characteristic and distinctive, and both require different qualities in the material to be used. In our last article only house painting was considered, although much that was said in regard to durability in that article, will apply equally well to varnish. This is especially true of mechanical injury, the action of deleterious gases, the destruction during cleaning, and the action of water, which, as will be remembered, were cited among others as causes for the deterioration of paint. Indeed, we really do not know of any additional cause, beyond the seven mentioned in the last article, which interferes with the life and durability of varnish, except, perhaps, its cracking, and upon this point we are hardly yet prepared to express any positive opinions. In what follows we will endeavor to recognize the two kinds of painting.

In order that paint, to be used for house painting and analogous purposes, should work well, two or three points seem to be essential. First, it must not run off the work; second, the brush marks made during application must disappear later; and third, the work must not appear spotted or streaked. In general these qualities are obtained by what is commonly known as proper mixing, although the grinding, the purity of the oil, and the kind of dryer used all have influences.

The running of paint may be due to two or three causes. The paint may be applied too thickly for the kind of paint used; for example, to put on as thick a coat of very thin paint as paint containing a larger percentage of pigment, would inevitably result in the paint running. Of course linseed oil alone can be applied to a surface with a brush without running, provided too much is not put on, and the greater the percentage of liquid in a paint, the thinner the coat must necessarily be. This application of thin coats is a very common fault, especially in contract painting. Where the pigment is strong in coloring and covering power, the temptation is to put on very thin coats, which temptation is increased by the fact that thin coats dry quicker than thick ones. Of course with proper care in using a very thin paint, there need be no difficulty from running. Another cause which may lead to running is want of proper grinding. The finer and better mixed the pigment and liquid are, the less the tendency to run. A paint mixed up by simply stirring the dry pigment into the liquid, is more apt to run than one which has been ground. The oil leaves the coarser portions of the pigment, and carries off the finer portions with it, resulting in streaks down the work. With proper proportions between the liquid and pigment, this difficulty can be obviated, but some pigments, as is well known, cannot be ground, and are therefore always used by simply mixing with the liquid, but a paint otherwise good and properly proportioned may give difficulty from running, if it was not finely enough ground. Still another cause of running is too long a time after the paint is put on before it sets. We have mixed up two paints, one of which would take a set, although not dry, in from six to eight hours, and another which would not take a set in twice that time, the amount of pigment and liquid and the grinding being exactly the same, and the second would run, while the first would not. It is very easy to see why this should be so. A thin layer composed of liquid and pigment, maintaining its limpidity, and being in a vertical position for a long time, will run off from the surface more readily than one which does not maintain its limpidity, although other things are the same. The paint which takes a set, thereby loosing its limpidity, resists the strain which produces the flowing or running in the other paint. Adulterated oil, especially linseed oil, containing petroleum product, is liable to this same difficulty, and for the same reason,

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the Journal for December, is on the Work of the Chemist on a Railroad; No. II, in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils; No. VIII, in the July number, on the Method of Purchasing Oils; No. IX, also in the July number, on Hot Box and Lubricating Greases; No. X, in the August number, on Battery Materials; No. XI, in the September number, on Paints. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these Contributions to Practical Railroad Information of special value in indicating the true character of the materials they must use and buy.

namely, the oil on the surface maintains its limpidity for a long time, thus giving gravity a long time in which to act upon the paint. The obvious remedy for running due to this cause is to use such an amount of dryer, with pure oil, that it will take a set in from four to eight hours, and where the difficulty is due to adulterated oil, the remedy is apparent without explanation.

The difficulty of the brush marks remaining prominent in paint is largely a question of the relative amounts of liquid and pigment, although not wholly so. The nature of the liquid used comes in as an element. For example, if a large amount of very thick japan is a constituent of the paint, or a heavy, viscous, boiled oil, other things being equal, the brush marks will have a tendency to be more prominent than where raw linseed oil and a limpid japan are used, but the proportions of liquid and pigment are, nevertheless, in all cases the important consideration. If the liquid is viscous and sluggish in movement, less pigment is required; with a very limpid liquid more pigment can be used, without causing the brush marks to be prominent. It is also quite probable that the grinding has an influence on the degree of permanence of the brush marks. Coarsely ground paint, under no circumstances, would allow the brush marks to flow out as readily as where the pigment is in a very fine state of division, and with that perfect union between the pigment and the liquid which is produced by fine grinding.

Streaked or spotted painting may be due to two or three causes. It often happens that the pigments made use of are what may fairly be termed "composite," by which is meant different chemical substances constitute pigments, and often in cases where the pigment is nearly all one chemical substance, as in chrome yellow or white lead, it frequently follows that materials made at different times differ in both shade and fineness, but are subsequently mixed together. In all cases where a pigment is composite our experiments seem to indicate that there is a tendency for the very finest particles to separate from those which are coarser, so that each successive brushful taken out of the bucket may contain a larger percentage of the fine, and a smaller percentage of the coarse particles than the previous brushful, at least while the first half of the bucket full is being used out. In some paints it is actually noticeable that the last end of the job is of a different shade from the first, especially if the painter has not stirred his bucket of paint frequently. This separation of the different constituents of the paint is also especially true of those composite pigments which are made up of some heavy bases, with some organic or light coloring matter; for example, Tuscan red, which, as is well known, is a mixture of oxide of iron known as Indian red, with some of the red lakes. It may fairly be claimed that this difficulty of spotted or streaked work is more a question of care on the part of the painter than of the proper mixing or proportioning of the paint, and this is to a certain extent true, but it is not wholly so. Poorly ground paint is especially liable to give streaked results, and no amount of subsequent stirring or mixing on the part of the painter will make a pigment consisting of very coarse and very fine particles a good one to spread, or make it give a good-looking job. Both fine grinding and great care on the part of the painter are essential to obviate this difficulty. It of course goes without saying that those pigments which, from their nature, have a tendency to produce this difficulty, should not be mixed where it can be avoided, although in our belief fine grinding will almost entirely overcome it with any pigments, whatever they may be.

It will be observed from above discussion that the essentials of good working house paints are fine grinding, pure oil, proper mixing, and the proper amount of dryer, together with good judgment and care on the part of the painter. Of these essentials the grinding and the use of pure materials are incumbent on the parties furnishing the paint. The proper proportioning of the pigment and liquid, the use of dryer of the right kind and in the right amount, and the skill and care during the application, are incumbent on the foreman painter or his subordinates. It may be thought that in treating this subject of the proper application of the paint, the brush may be regarded as an essential element, and this undoubtedly does have an influence, especially in brush marks. However, our experience indicates that this element is less important than would generally be thought, as a skillful painter, even with a poor brush, will make a good job, where an unskillful man with a good brush fails. We think it fair to say, however, that it is more wearisome to the arm, and more difficult to get good results with stiff brushes than with those which are more soft and pliable; also in our judgment there is very little economy in using poor brushes.

The proportioning of pigment and liquid to give good spreading paints, as well as how to proportion pigment and liquid in paint for grinding, both will be taken up a little later. We have made some very positive experiments on these points, and hope to be able to give a rule which will approximately, at least, enable successive batches of paint to be mixed so that they will work alike, and also possibly enable new pigments to be mixed for grinding without the necessity for going through with preliminary experiments. If we succeed as well as our experiments promise, the rule which we give will eliminate the uncertainty due to the addition of indefinite amounts of liquid to paste, and eliminate also the individual judgment of the painter, which is now, unfortunately, not rare, and to which, perhaps, some of the difficulties now experienced with paints may fairly be attributed.

Coach painting, as has been stated above, being almost entirely a question of color, requires that the paint when applied, shall be considerably different from that used in house painting. In the latter case somewhat of a gloss is desirable, and quite a large quantity of linseed oil is essential with our present knowledge of paint liquids. In coach painting, on the other hand, a large quantity of linseed oil is fatal, and no gloss is desired in the dried paint. It is not our intention to give a treatise on coach painting, beginning with the wood, and coming up to the final coat of varnish, as at present the question of surfaces, which make the ground work for the color in coach painting, has not been sufficiently studied; also varnish has not yet been sufficiently studied to make us willing to publish anything in regard to it. The color used in coach painting, however, we have studied somewhat, and this is the material the application of which we are discussing. In addition to the points mentioned above, which are requisite in order to secure good house painting paints, namely, fine grinding, pure materials, proper mixing, proper kind and amount of dryers, and care and good judgment on the part of the painter, there are some difficulties which are characteristic of coach painting which do not occur, to any great extent, at least, in house painting. These difficulties are such that, as we understand the matter, the additional requisites of a good coach color are, it must not dry too quickly, it must not roll up under the brush, it must dry "flat," and it must cover the surface.

Where coach color dries too fast, it is impossible to brush it out smooth, and also to join on to the work last finished, with the next application. As is well known, coach color is almost always applied to a prepared surface, formed by laying on the wood or iron a foundation of surfaces of some kind, and rubbing these down to get a flat and smooth surface almost impervious to the color. In order to get the paint evenly spread, therefore, over this prepared surface, a proper amount of brushing is necessary, since, as is well known, each full brush leaves more paint where it first touches than on the surface coated with the remainder of the stroke. If, now, the paint dries too fast, it is impossible to give it sufficient brushing to get the surface evenly covered. Furthermore, as is clearly evident, the whole side of a car body or other portion of the same cannot be coated at once. Successive portions within reach of the painter are coated, and then by change of position, the contiguous portions. In joining, the paint being applied to that previously applied, it is not infrequent that serious difficulty occurs, and this is always true if the paint dries too fast. In this case the paint, which has already been on for some time and is partially dry, rolls up under the brush and gives a bad looking job. Too large a percentage of dryer, or not enough turpentine, are the probable causes of too rapid drying. Of course the constitution of the paint has an influence; for example, with a paint ground in japan alone, the proportion of the di-

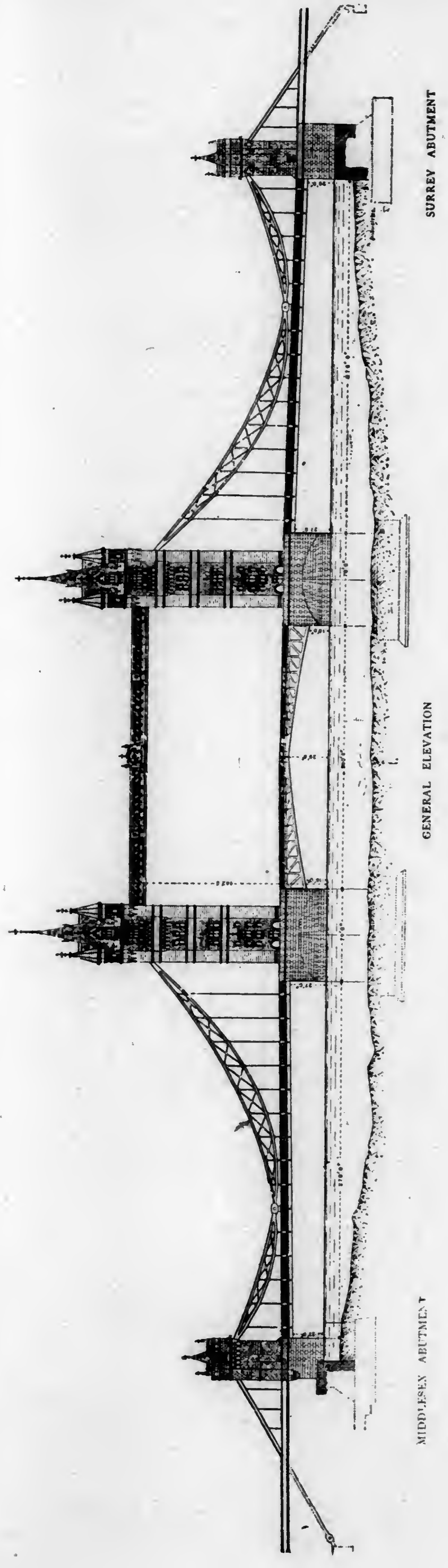
luting material added, either turpentine or oil or more japan, would have to be different than with a paint ground in oil and turpentine, but we think it will be found in general that the proportion of turpentine on one side, and the japan and oil on the other, are the variables which control the drying.

The rolling of coach color under the brush is due to two causes—either too rapid drying, or to being mixed too thick. If a brushful of paint cannot be applied to a surface, and the surface be gone over several times with the brush, so as to secure an even covering, as is above described, without the paint rolling up under the brush, it is evidence that the paint dries too rapidly as already explained, or that it contains too much pigment for the liquid. In practice we believe it is generally due to both causes that coach color rolls up under the brush, and the most common remedy is simply to add turpentine which both retards the drying and at the same time dilutes the paint so as to give a more limpid material.

Flat color, as is well known by those accustomed to painting, is simply a coat of paint without any gloss. In coach painting it is believed to be absolutely essential that the color should dry "flat," since if the color has gloss of any kind, the subsequent application of the varnish is not successful, since the varnish crawls off from a glossy surface, leaving spots, the tendency being for the varnish to assume the form of globules on the surface, rather than to lie in a thin layer over it. With color which is sufficiently flat, and with a good varnish, this result does not take place. There has been some study made as to what produces flat color, some claiming that it can only be produced by japan and turpentine, and that no linseed oil must be present; if so the color cannot be made flat, since linseed oil usually dries with a gloss. We have made a number of experiments on this point, and are inclined to think that flat color can be produced with any liquid, even with varnish, which, as is well known, always dries under proper conditions with a gloss, and is used for that purpose. Our experiments indicate that the explanation of flat color is as follows: For purposes of application paint must be made thin enough so that it will spread with a brush. A paste sufficiently thick for this purpose, at least, cannot be spread with a brush. This thinning of paint for spreading purposes is usually done with oil, japan and turpentine. When the paint comes to dry, the turpentine, or at least by far the larger part of it, evaporates. The non-volatile part of the japan and the oil are left behind, and hold the pigment on to the surface after the chemical change called drying has taken place. If, now, the ratio of pigment to binding material, comprehending under the words binding material the substances which hold the pigment to the surface, namely, the non-volatile part of the japan and the oil, is, say, 50 parts pigment to 40 parts binding material by weight, the paint will have more or less gloss, depending some on the nature of the binding material. This ratio of 50 to 40 by weight, however, only holds for pigments which have about the specific gravity of Venetian red, Tuscan red, Indian red, etc. If, on the other hand, the ratio of pigment to binding material is about 75 parts pigment to 10 or 12 parts of binding material, the paint will be flat, and our experiments indicate that this is the case whatever may be the binding material. The same restriction as to specific gravity of pigment holds in this case likewise. We have actually obtained perfectly flat color by taking a paste ground in oil and turpentine, where the oil was only about 8 per cent. of the weight of the paste, and diluted it with turpentine, so that it could be spread, and obtained perfectly flat color without any japan whatever. We are confident flat color is simply a question of proper ratio between pigment and binding material. It is fair to say that many of the pigments cannot be ground in a small enough amount of oil, so that by dilution and spreading flat color can be obtained. For example, Tuscan red requires 75 parts pigment and 25 parts oil in order to grind fairly well. With this ratio of pigment and oil, the oil subsequently becoming the binding material, flat color cannot be obtained. This difficulty has led the manufacturers to grind many colors in japan, or oil and turpentine, the more common practice being, we believe, to grind in japan alone, and it is possible this practice has led many to think that japan was essential in obtaining flat color. Upon the question of grinding for flat color, we prefer oil and turpentine rather than japan, for reasons which will be given when we come to discuss our specifications for Tuscan red; but irrespective of the material used in grinding, we are confident that any color can be made flat if the amount of binding material, when the paint is dry, bears a sufficiently small ratio to the pigment. If this statement is correct, it will be seen that the mixing of paint for flat color is not a very simple matter. If the color is ground in japan alone it is possible that simply diluting with turpentine may give what is required. If the pigment is ground in oil and turpentine some japan must, of course, be added, and then turpentine to dilute with. There is need of definite figures as to the ratio of pigment to binding material for all colors. We have not yet had time to go over the ground, but possibly may succeed a little later in giving a rule which will apply to various colors.

The difficulty just mentioned, of not having so much binding material that the paint will not dry flat, causes coach color, when mixed for spreading, to be very thin, since it contains so large a percentage of turpentine, and unless care is taken, the color will be so thin that it will not cover the surface. Indeed, as is well known among practical painters, coach color mixed to dry flat requires at least three coats to get the proper amount of color on the surface, whereas as required for house painting two coats will give a layer as thick or thicker even than three coats of coach color. If too much turpentine is used, making the paint, as said above, too thin, the only real serious difficulty is that a good many coats must be put on in order to get the requisite body of color, and it is also of course obvious that, other things being as they should be, the remedy for this state of affairs is not to use too much turpentine in diluting coach color. This, however, is not all of the problem, as will appear from what follows. In our view of the case there is a radical distinction, which will be brought forward a number of times as our discussion of the paint problem continues, between the pigment used in house painting and the pigment used for coach color, and we hope to make clear later, in discussing house painting, that the pigment may be largely some inert material, only enough coloring matter being required, in our judgment, to give the proper shade. Of course if this amount of coloring matter is not enough to make the material cover well, it will be necessary to add to the inert material some good covering pigment. These points will be worked out in detail in a subsequent article. It is sufficient for our purpose here to say that, in paints to be used for house painting, such for example, as all the oxide of iron paints, the ochres, etc., it is not essential to have all the pigment oxide of iron, or the hydrated oxide of iron, which is the characteristic coloring matter of the ochre. A very large percentage may be inert material, and yet perfectly satisfactory results obtained. Not so, however, with colors to be used for coach painting. In these paints color is the thing desired, and from the necessities of the case, as has been explained above, each successive coat must necessarily be thin. If, therefore, the pigment is only one-third or one-half coloring matter, in any good paint to be used for coach painting, it is obvious that more coats will be required to get the same amount of color on the surface than if the pigment is largely, or, in fact, nearly all coloring matter. To give an illustration: if a sample of Tuscan red is 75 or 80 per cent. red oxide of iron and 15 per cent. organic coloring matter, three coats will give a fine body of color on a properly prepared surface. If, on the other hand, the same Tuscan red is mixed with one-half sulphate of lime, it will be found that three coats show a much less depth of color and a great tendency to streakiness. This we have actually found by experiment, so that the covering power of coach color is not wholly a question of thinness of the paint. Almost equally important, and perhaps more important, is the constitution of the pigment.

Accordingly, while, as will appear later in our specifications for paint to be used for house painting or analogous work, we allow large quantities of inert material, we do not, on the other hand, in our specifications for coach color, make any allowance for inert material beyond the neces-



THE TOWER BRIDGE OVER THE THAMES, LONDON, ENGLAND.

sary impurities of commercial pigments. We have already been criticised somewhat by old coach painters for allowing too much inert material in our house-painting paints, and on the other hand some of the paint manufacturers who have been accustomed to use large quantities of inert material in their ready mixed paints, and only small amounts of color for tinting, think our specifications for coach paints altogether too severe in not allowing some chance for inert material. We are confident both these parties will ultimately approve our course before we finally finish with our discussion of the paint question, and we are likewise confident that both parties are right from their own standpoint. The difficulty arises in confounding the two kinds of painting—coach painting and house painting. A paint which will give perfectly satisfactory results when used for house painting, its appropriate method being used both in the preparation and application of the paint, will be worthless for a coach paint. On the other hand, a pigment that is valuable and in every sense satisfactory as a coach paint, although it would work well enough, and possibly give good results, when used for house painting is, nevertheless, very much more expensive than is necessary for a house paint, and will not, if our reasoning and experiments can be trusted, give any corresponding increased durability or benefit in keeping with the increased expense. No doubt this proposition will hardly be accepted by many old painters. We ask them, however, to hear us through and follow our reasoning and experiments before they finally condemn us.

In the next article we will speak of the drying of paint, and if space permits, of covering power.

(TO BE CONTINUED.)

THE TOWER BRIDGE AT LONDON.

THE accompanying illustration, which is taken from *Industries*, gives a general view of the Tower Bridge, which is now being constructed over the Thames River in London. The work was begun in 1885 and is now well advanced, although it has been delayed by many causes. The piers are now completed and the superstructure is being erected. The bridge is farther down the river than any of the existing bridges, and is at a point below many of the large wharves, so that it was necessary to provide passage for vessels of considerable size. A fixed low-level bridge was not possible. An ordinary low-level drawbridge would entail a total stoppage of traffic when the bridge was open, while a high-level bridge or a tunnel under the river would require approaches with such grades as to render the crossings practically useless.

The form of bridge ultimately decided upon, and which is now being carried out, will, it is thought, offer the minimum obstruction to the shipping interests, while at the same time it will provide in the best manner for the street traffic, especially for foot-passengers, who will be able to pass over the bridge at all times.

The distance between the North, or Middlesex, abutment, and the South, or Surrey, abutment, is 880 ft. Two massive masonry piers, each 70 ft. wide, have been built in the bed of the river, and have centers 270 ft. apart, so that the central or opening span is 200 ft. clear. The side or fixed spans are each 270 ft. clear. The total length of the whole bridge, including the necessary approaches on both sides of the river, is 2,640 ft. The roadway along the approaches and side spans will be 60 ft. wide, but over the central span it will be reduced to 50 ft. Nowhere will there be a steeper gradient than 1 in 40, which compares very favorably with London Bridge, where the gradient is in some places 1 in 27. Notwithstanding the very large piers necessary for this type of bridge, the sectional area of the waterway is 20,040 square feet, which is rather in excess of the dimensions at London Bridge, where the area is 19,300 square feet.

With the gradients above referred to, it is not possible to give greater head-room for vessels than 29 ft. 6 in. at high water, but this will be sufficient for the bulk of the river traffic. There are, however, on the average, some 22 vessels passing per day which require a much greater head room than 29 ft. 6 in., and for their benefit the cen-

tral span of the bridge will consist of two immense leaves, which will weigh nearly 1,000 tons each, and which will be so nicely balanced, that they may be easily rotated in a vertical plane by hydraulic machinery on the piers. When these leaves are raised into a vertical position, the head-room will be about 140 ft. for the clear width between the piers, which will be ample for all the vessels which navigate this part of the river. While the bridge remains thus open all vehicular traffic must be suspended, but in order not to interrupt foot-passengers crossing the bridge at all times, there will be provided two permanent gangways over the central span at a height of about 140 ft. above high water. These will be each about 12 ft. wide, and at each end there will be large hydraulic hoists for the convenience of people using these high-level footways.

The work was divided into seven sections and, as stated above, is now well advanced, in spite of many delays. In building the piers and approaches about 10,000 cub. yds. of stone and 70,000 cub. yds. of concrete were required, while in the superstructure about 15,000 tons of iron and steel will be used. The machinery for working the opening span and the passenger elevators in the piers will consist of eight hydraulic engines and four hydraulic lifts, with six accumulators and two steam pumping engines of 360 H.P. each.

The superstructure is almost entirely of steel, manufactured by different firms. The preparation and erection of this part of the work is under the charge of William Arroll & Company, of Glasgow, the general contractors. For the rolled steel a tensile strength of 27 to 32 tons per square inch is specified, with an elongation of at least 20 per cent. Siemens-Martin steel is used and careful tests are made of all the material. The Chief Engineer is J. Wolfe Barry, whose design is certainly striking and original. The bridge, it will be seen, consists practically of two separate stiffened truss suspension bridges, the central piers or towers being connected by a girder, which also forms the high-level crossing.

THE ACCIDENT TO THE SAULT CANAL LOCK.

(From the Cleveland *Marine Review.*)

COLUMN descriptions of the recent accident at the Sault Lock failed to describe intelligently the workings and machinery of that important gateway between Lake Superior and the lower lakes. At least, very few vessel owners, shippers, and marine men in general understood just where the trouble was. The *Review* gives detailed drawings showing the break, and adds others which illustrate the workings and plans of this lock, through which has passed during the last nine years $519,254,065 worth of freight, carried by 58,323 vessels, for which the lock was opened and closed 29,267 times. During 234 days of 1889, 9,579 boats, with tonnage of 7,221,935 tons, passed through this canal, while only 3,425 boats, with tonnage of 6,783,187, passed through the Suez Canal. Were all this traffic thrown on the lines of railroad, they would be hopelessly blockaded, and the retarded circulation of commerce resulting would more seriously affect the financial condition of the country than any one other feature of transportation.

Figs. 1 and 2 represent the north emptying valve beneath the lower gate, in a tunnel that extends from the well *Y* to the well *Z*, whence it discharges into the canal. This valve, as is shown in fig. 1, is in the tunnel midway between the wells, and almost directly under the miter-sill. It is 10 ft. wide by 8 ft. deep, and moves on a trunnion, which has bearings in a heavy iron frame bolted to the culvert or tunnel. The valve consists of a cast-iron frame covered with boiler-iron. Lugs from the valves attach to a pitman, connected with a piston-rod which is operated by water cylinders indicated by *L* in fig. 4. Water from an accumulator, with a cylinder 21×24 in. and capacity of 1,859 galls., may be admitted to either end of the 15-in. water-engine cylinders. This power is obtained from two 30-in. turbines geared to a main shaft, and fed through a supply pipe, *B C*, fig. 4, from the canal above the lock. A belt from the shaft runs two force-pumps, each having three plungers, which pump into an accumulator loaded so as to give a pressure of about 120 lbs. to the square inch. Water is taken from the accumulator to the engines operating the gates and valves.

As is shown in fig. 2, the trunnion to this valve, falling back under a pressure of 45 tons to position, twisted the connecting-rod of the water cylinder. The cap square was also broken, the breakage being attributed by some to

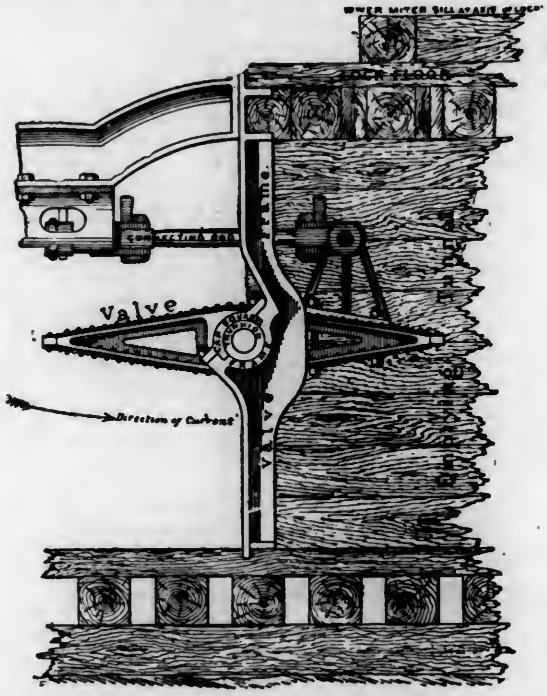


Fig. 1.

the jar caused by blasting with dynamite for the new lock. The gateway of the northwest was closed, the Colossus of Locks had closed business for a summer vacation, while 265 vessels, valued at $16,489,000, with $2,525,550 worth of cargo and 1,362 passengers lay motionless.

The diver secured the broken pieces of the trunnion, 6-in. hollow cast steel, over which a wrought-iron wrist

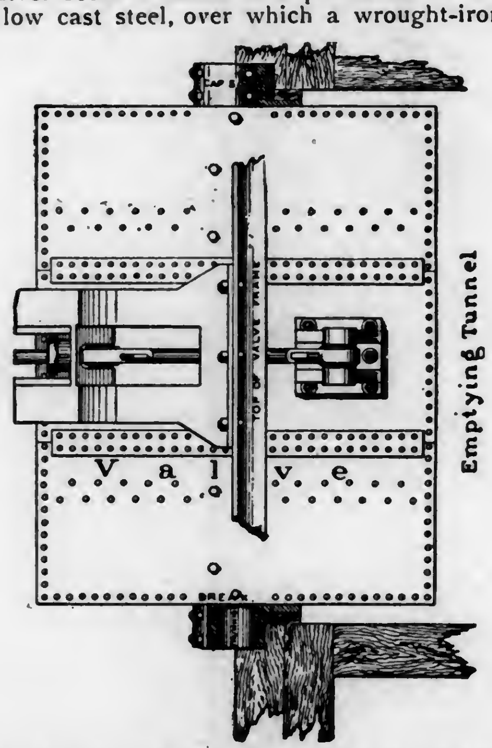


Fig. 2.

had been shrunk last winter. A piece of 4-in. steel was threaded, and an old cap square repaired, so that when the lock was pumped out the repairs were quickly made by putting the bar of steel through the hollow trunnion and bringing the broken parts together.

The repaired cap square was put on, the twisted connecting-rod was straightened, and the filling of the lock was all that was necessary for the delayed fleet to resume

movements, 81 vessels being locked through the second day that the canal resumed operations, 87 on the third day, and 85 on the fourth. The shock that probably caused the accident seemed to shake up the Northwestern railroad presidents and boards of trade until the influence was felt at Washington, so that amendments will likely be made to

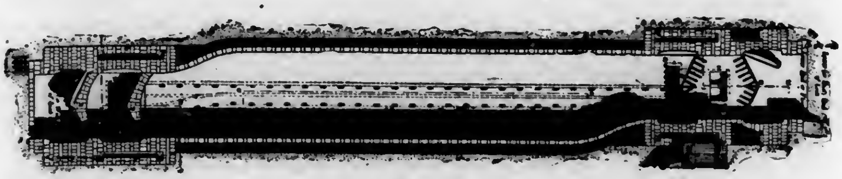


Fig. 3.

the River and Harbor Bill that will give $900,000 to the new lock and approaches for the coming year, and provide that contracts be entered into for the entire structure.

The lock in use at present was commenced in 1873, after plans advised by General Poe, and was completed in 1881. The chamber of the new lock is 515 ft. long, 80 ft. wide.

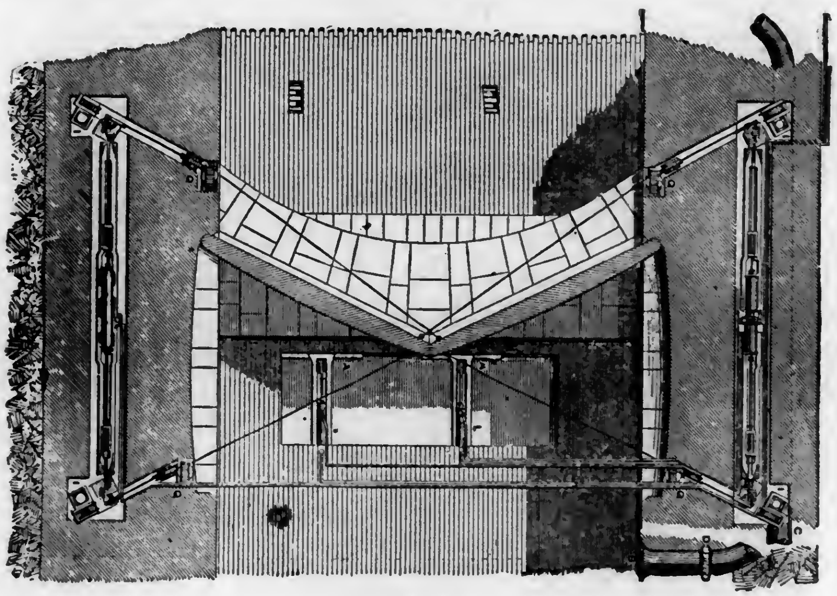


Fig. 4.

except at the gates, where it is 60 ft., and the depth is 39½ ft. The lift of the lock is 18 ft. and the depth on the outer sills is from 16 to 17 ft. The protection built last winter for these sills could be seen when the lock was emptied to make repairs, and the torn bar-iron and scarred frames indicated the wisdom of its construction, although there was some objection to it at the time. A guard-gate at either end makes the extended walls 717 ft. long. They are 13 and 25 ft. wide at varying distances. About 35,000 barrels of cement and 34,207 cub. yds. of masonry were used in the walls. In the miter walls for the upper lock and guard-gates there are nine courses of cut stone, each 2 ft. thick. The walls are 14 ft. wide at the miter angle, are arched to resist the pressure on the gates, and are bonded into the lock walls. The top course of stone is set back 1 ft., so as to leave an offset, on which the oak miter sills rest; these sills project 2 in. above the masonry.

The foundation is on rock throughout. In excavating the lock pit, rock was reached at from 1 to 15 ft. above the grade of the lock floor. A floor of timber and concrete extends across the bottom of the lock and 5 ft. under each wall; the rest of the wall foundation is concrete, 6 in. to 2 ft. thick on the rock. All the foundation timbers are of pine, 1 ft. thick. The miter sills are of oak 12×18 in., and are held in place by bolts 10 ft. long, fox-wedged and concreted in the rock, and also by timber braces bolted to the rock.

The four gates, two being guard-gates used only in case of accident and for repairs, are shown by *P Q R S* in fig. 3. The weight of one leaf of the upper gate is 40 tons, while a leaf of the lower gate weighs 76 tons, being made of white oak and Norway pine. The position of the four gate engines, which are operated by water taken from the accumulator, are shown by *J J J J* in fig. 3. Each cross-head is constructed with two sheaves. One end of a wire rope is adjustably fastened at *I*, fig. 4, and, passing around one of the engine sheaves, is led by suitably located sheaves down through the well in the lock wall, around the drum *Q*, and to a leaf, to which it is secured. The four ropes necessary for the opening and closing of each gate are clearly shown in fig. 4. When the engine makes a stroke, the end of the rope attached to the gate moves four times as far. With a pressure of 200 lbs. per sq. in., the total pull on the leaf of the gate is 8,835 lbs., less friction and rigidity of rope. In case the gates should be carried away, provision has been made by means of a movable dam 3,000 ft. above the locks, for the closing of the guard-gates.

Water is let into the locks from culverts under the floor, extending from the well *X*, fig. 3, above the upper lock gate, to the well *Y*, above the lower lock gate. The two culverts are separated by a longitudinal bulkhead, and each is 8 ft. square. The floor of the lock forms the roof of the culverts. The water passes into the lock chamber through 58 apertures in the floor, shown in fig. 3. The total area of these apertures is 174 sq. ft.; this outlet area is increased to 190 sq. ft. by man-holes left in the bulkhead at the lower end of the culverts. The combined area of the cross-sections of the two culverts is 128 sq. ft. Having the inlet area considerably less than that of the outlet tends to diminish the velocity of the water when projected upward into the lock chamber. The water in passing out of the lock goes down through the well *Y*, which, as well as the well *X*, is covered with a grating, thence through short culverts, and up through the well *Z*. The valves in the culvert through which the water enters are the same as the discharge culvert valves already described.

The first lock was constructed during 1853, 1854 and 1855 by the State of Michigan, to which Congress made a grant of 750,000 acres of land for the purpose. Previous to 1845, several brigs in the fur trade were the sum total of the fleet on Lake Superior; but the discovery of copper made the portage of the Sault Rapids an important one, and with the discovery of iron ore came demands for the canal—the first ship canal in the United States, and at that time the largest in the world. The Sault Rapids, which have made the canal and lock necessary to lake navigation, are one-half mile long, and have a fall of about 17 ft., the fall from Lake Superior to the Sault being one-tenth of a foot, and thence to Lake Huron about 2 ft. For a few years vessels were transported on ways to the head of the rapids, and then relaunched, and for a short time a horse tramway did an extensive business between the foot and head of the rapids. The first canal cost $1,000,000, and was 5,400 ft. long, 100 ft. wide and 12 ft. deep. The present canal, with a depth of 16 ft., was completed but a short time when the increase of commerce demanded greater facilities, and the work of making a channel 20 ft. deep was undertaken. It consists of the construction of a new lock on the site of the old State locks, to be 800 ft. long, 100 ft. wide and 21 ft. on the miter sill. This will enable shipbuilders to design boats on lines which are known to give the greatest carrying capacity, while at present they are hampered by making ships comply with the narrow depth. The estimated cost of the new lock and improvement is $4,738,865. One million has been appropriated, and up to June 30, 1889, $250,331 had been expended, and the remainder of the appropriation was covered by contracts. The lock in use at present cost $2,404,124. The cuts are from drawings furnished by Colonel O. M. Poe, U. S. Engineers.

THE DEVELOPMENT OF ARMOR.

BY FIRST LIEUTENANT JOSEPH M. CALIFF, THIRD U. S. ARTILLERY.

(*Continued from page* 412.)

XVIII.—THE SCHUMANN-GRÜSON CUPOLA.

IN the Grüson system, previously explained, chilled cast-iron alone is used. To be effective, however, cast-iron has to be employed in very heavy masses, which precludes its use in cases where moderate weight and ease of manipulaipulation are requisites. Wrought-iron largely, and steel to a less extent, have been used in armored forts and batteries. To some extent compound plate has been employed, but the difficulty of curving a plate of this character without destroying the union between the hard face and soft iron back is a serious obstacle to its use. It is believed to be a safe prediction that cast-iron and steel will be the metal chiefly employed in the armored fortifications of the future.

The Schumann-Grüson or German cupola was designed by Major Schumann, of the Prussian Engineers, and manufactured by the firm of Grüson, of Bockau. While externally presenting much the same appearance of the Grüson cast-iron cupola, it differs from it in several important particulars. Fig. 1 gives a general idea of the structure, which consists of two principal parts—(1) a fixed outer glacis ring of chilled iron blocks or segments, and (2) of a curved umbrella-shaped oscillating shield, made up of six segmental side and two hexagonal roof-plates, each 8 inches in thickness.

The glacis ring is set in concrete, which protects the turret proper from its base up to the height of the gun ports, and is itself protected by a concrete slope 9 ft. in thickness. In the first experimental cupola constructed upon this plan, half of the segments of the turret were of wrought-iron, the remainder of compound plate. The behavior of the compound plate under fire was so unsatisfactory that its use is believed to have been abandoned in this system.

The shield does not permanently rest upon the glacis ring, but its entire weight is taken on an 8-in. central pivot. By means of a socket piece, collar and gearing the shield can be raised or lowered about 6 in., allowing it to rest upon the glacis ring or raised from it when in the firing position. The whole structure is free to oscillate on the rounded head of the pivot. To take up the force of recoil of the guns, as well as that from the blows of projectiles, the lower edge of the shield is provided with legs set in journal boxes and having strong volute springs. These legs rest on trucks running on circular roller-paths fixed to the inner top angle of the glacis wall.

The two guns are mounted side by side, and, by means of rings carrying trunnions shrunk on near the muzzle, are pivoted in recesses formed in the inner skin at the sides of the ports. The force of recoil is transmitted to the structure by means of a pair of vertical arcs in rear of the breech of each gun. Elevation is given by quadrant by the aid of the gradations on these arcs. The preponderance of the gun is slightly overbalanced by a counterpoise weight suspended by chains passing over pulleys and attached to a crossbar passing under the gun in front of the breech mechanism. To give elevation the breech is hauled down by means of a chain and windlass. The turret can be rotated by means of pinion gearing actuated by winch handles. Through the top and in rear of the center of the shield is a hole sufficiently large to admit the head of the man who sights the guns, to which access is had by a light iron ladder.

The central idea of the Schumann cupola is that the guns, shield and gearing are rigidly connected, and that the entire force of recoil shall be absorbed in the oscillation of the whole mass.

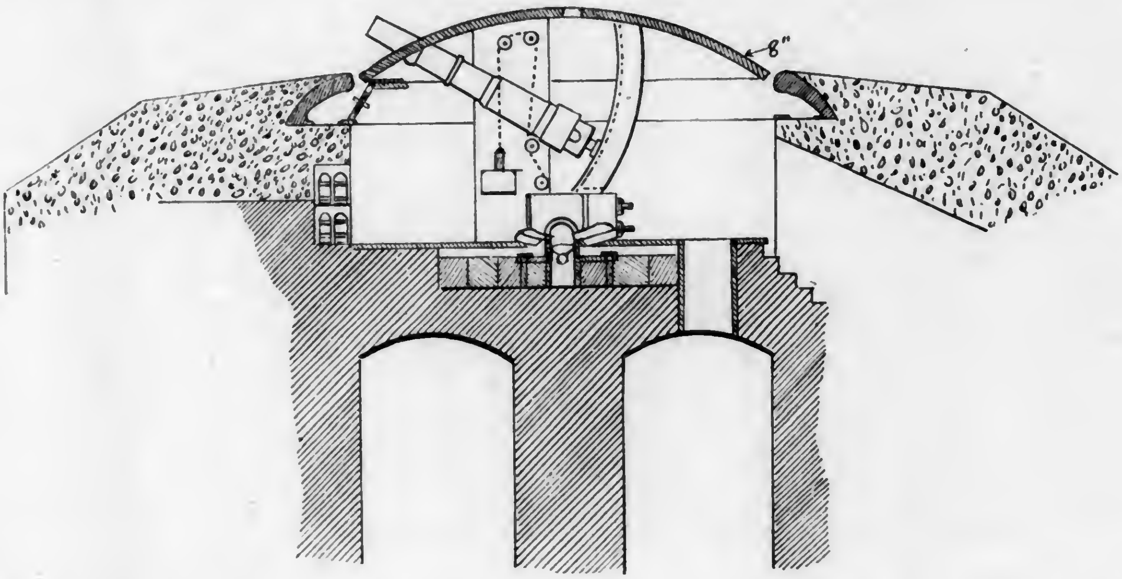


Fig. 1.

The pit is a single circular chamber 19.5 ft. in diameter walled with brick, with its floor-level about 3 ft. below the natural surface of the ground.

Major Schumann is also the designer of many of the defensive structures made by the firm of Grüson, which are being largely adopted by the Continental powers. In addition to the one already described there is a disappearing cupola for a 12-cm. gun—the heaviest ordnance, the designer holds, that should be mounted in such a structure; disappearing cupola for quick-firing guns; traveling shield for light guns, and a spherical shield for mortars, all of wrought-iron, except the first, which is of steel. In addition, he has designed an elaborate fortification or battery, consisting of a central disappearing cupola, with an auxiliary defense of ditches, abattis, quick-firing guns and mortars.

During the manœuvers of the German army last year the position taken up by the defensive portion of the troops was strengthened by eight Schumann iron-clad towers, armed with quick-firing guns. These towers or shields were simply small revolving turrets, resembling beehives in outward appearance, mounted on wheels, and, in the absence of horses, were drawn by soldiers, and each manned by two artillerymen. The shields were of 1½-in. steel, and supposed to be bullet and splinter proof.

XIX.—THE FRENCH OR MOUGIN TURRET.

This turret, designed by Major Mougin, of the French army, and manufactured by the Saint-Chamond Company, Loire, is shown in fig. 2. Like the Schumann-Grüson turret, just described, the armored portion of the structure consists of two parts—the glacis-ring and the turret proper.

These are contained in two circular chambers, one above the other, the upper one, containing the guns, being on the natural level of the ground, the lower one the hydraulic pivot. The glacis-plates, of the form shown, are of cast-iron, set in concrete, and protected in front by a mass of the same material.

The turret proper is of wrought-iron 18 in. in thickness and with an exterior diameter of 15.7 ft. The top is closed by a 7.2-in. wrought-iron plate, in two sections, mortised together, and is let into rabbets in the walls and secured by screw bolts. The turret is mounted upon what is called a "floating pivot." It rests upon a built-up annular box girder, which in turn is secured by means of brackets to a heavy casting that rests upon a 10½-in. steel pivot, about which the turret revolves. This pivot rests in a steel-lined cast iron cylinder containing glycerine, which supports the entire weight of the structure—something over 100 tons. By means of a hand pump the whole movable portion of the turret can be raised so that little or no weight rests upon the rollers.

The turret is revolved by means of a double-purchase winch in the lower chamber. Horizontal and vertical rollers, upon a track of cast-iron bolted to the top of the pit wall guide and control the motion of the turret, but do not support its weight.

The two guns are mounted side by side, and to facilitate manœuvring, are each provided with a counterpoise weight

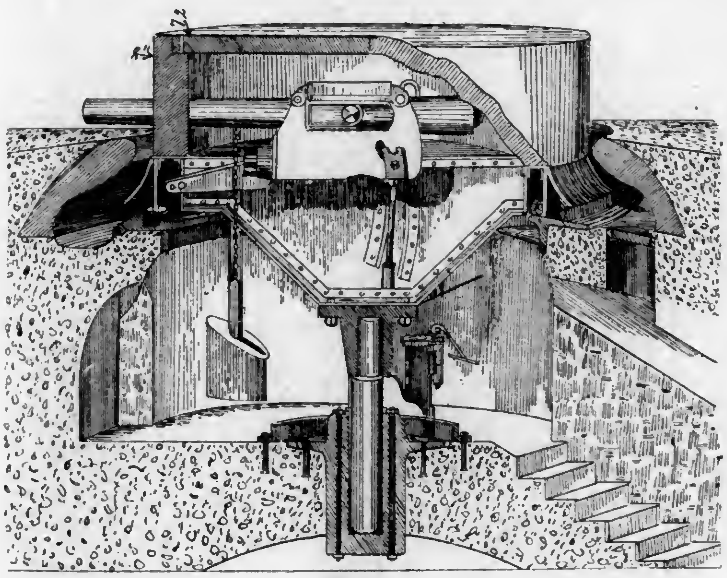


Fig. 2.

suspended in front of the central pivot, but having a preponderance of 1,100 pounds. The recoil is taken up by means of small hydraulic cylinders under the gun, one above the other, the piston in the upper cylinder being connected with the carriage. The opening between the cylinders is closed by a one-way valve which opens automatically during recoil, the force of which is made to compress a strong spring. By opening this valve the spring is released and the gun run into battery.

Excepting the gun-ports, there are no openings of any kind on the side toward the enemy, a door affording ingress and egress from the rear. Except the view obtained through the bore of the piece, the gunner has no means of knowing the character or position of the object aimed at other than from information received from the observing station some distance away. The guns have no sights; the elevation is given by quadrant. By means of a metal ring, graduated to degrees and quarters, the guns can be laid according to directions received from the operating station by telephone or otherwise. It is intended that the guns shall be fired by electricity and automatically. Movable contact-pieces, which may be clamped at any desired point on the pointing arc, are made to close a circuit and fire the piece. It would seem that the perfect immunity from rapid and machine-gun fire afforded by the properly closed turret is too dearly purchased when it deprives the officer in actual charge of the guns of any intelligent idea of the results of his fire, and makes him absolutely dependent upon exterior means and material which at any moment may become disabled.

In a turret of later design, Major Mougin employs a mushroom-shaped dome in place of the cylindrical turret, with interior fittings almost identical with those employed in the latter.

A disappearing turret has likewise been designed in which the cylindrical form has been adopted, the material to be steel-faced plates and the roof in one piece. The base is supported on the piston of an hydraulic press, which also serves as the pivot for the turret. No rollers are employed, the center of gravity of the structure falling well over the pivot. The turret has a vertical motion of one meter.

The certainty that high explosives will be used in the next great war has, in France, led to a new departure in the construction of defensive works. Major Mougin has designed a fort which is little else than a huge block of concrete, on the top of which are three cupolas, each mounting two 6-in. guns. Instead of soldiers, this peculiar structure is to be garrisoned by 30 or 40 skilled mechanics. Entrance is obtained only by a subterranean gate. To assist in the defense a double line of railroad, covered by a parapet, encircles the work, upon which trucks carrying guns can run, making it possible to reinforce, with this movable armament, any particular point of the work.

Two years ago some experiments were made at Chalons with a view of testing the merits of two truck turrets, used in connection with concrete glacis. The one, the Saint Chamond or Mougin turret, already described, and the other manufactured by the well-known Chantillon & Commentry Company. The latter made an important improvement upon the rotary Saint-Chamond turret, in adding to the rotary motion an ellipse movement, so that the turret not only turns on itself, but, by a simple counterpoise mechanism, drops down after firing, projecting then above the ground only about 6 in. These ellipse turrets are to be of cast steel, have a thickness of 50 cm. and each to weigh from 120 to 190 tons.

In carrying out these experiments the plan adopted was to divide them into two parts, first to fire from the turrets to test the turret mechanism, carriages and system of mounting, and afterward to subject the turrets themselves to cannonading. No professional reports of these experiments are at hand, but from the newspaper accounts it would appear that during the first series the turrets behaved exceedingly well, but that when subjected to fire the results were by no means as satisfactory, the turrets being badly shattered, and even the concrete failing to display the resistance expected of it.

XX.—THE BUCHAREST TRIALS OF ARMORED TURRETS.

During December and January, 1885-86, a series of trials was conducted near Bucharest to test the relative merits of the German and French turrets for land defense. This was done in view of the fact that the Roumanian Government had in contemplation the building of an extensive line of iron clad forts for the protection of its capital.

A Schumann cupola and a French cylindrical turret, constructed upon the lines given above, were erected, the former armed with 15-cm. Krupp, and the latter with 15-5-cm. guns, or both practically of 6-in. caliber. It was designed to test the turret mechanism by firing guns from the turret and the armor-plate by firing at it, thus bringing the experiment down to actual service conditions, subjecting both as nearly as possible to the same stress. The projectiles used were steel shell and the distances 1,000 to 300 meters.

From the German cupola 100 rounds were first fired, during which the turning and other gear worked satisfactorily, and finally, after the structure had been subjected to fire, 50 more rounds were fired at extreme elevation without injury to the mechanism. In the attack the cupola received 85 direct and 12 ricochet hits. Three of the six segments were of Wilson's steel-faced plate, the other three of wrought-iron. The effect upon the compound plates was

to crack the hard steel face, and ultimately to peel it off completely in places from the wrought-iron backing, practically breaking the plate. Against the wrought-iron plate the effect was insignificant, and limited to scooping out of the metal, without starting cracks or opening welds. Four effective hits were obtained upon the roof plate of wrought-iron, from a 21-cm. rifled mortar, firing a 176-lb. shell, producing only slight indents.

Against the French turret, which, it will be remembered, was of 18-in. wrought-iron, 63 direct and 9 ricochet hits were obtained. When the blow was delivered normal to the surface, the steel shell had a maximum penetration of about 9 in., and rebounded without great deformation; glancing blows simply gouged out a little of the metal. By concentrating the fire upon a small space the turret was practically breeched near the junction of the side and roof plates, but without materially injuring the interior or gear, or interfering with rotation.

Comparing the two systems, it was found that the springs in the guiding tracks of the German turret received a permanent set, and that the cupola at the end of the trial had a cant to the rear, arising from the fact that the guns being pivoted in the shield, the blows of recoil were always delivered in the same direction, and that the edges of the shield were not sufficiently protected. On the other hand, the umbrella shape of the German cupola was vastly in its favor, and it was found that its 8-in. plate, against which it was almost impossible to deliver a square blow, was practically about equal to the 18 in. of the French cylindrical turret, while at the same time the cupola presented a smaller and much less conspicuous target. In ventilation, lighting and methods of laying the guns, the German system was believed to be superior, while in ease of traversing, in the mounting, and in rapidity of fire the French was the better one.

The Commission appointed by the Roumanian Government to superintend these trials reported in favor of Schumann-Grüson system, and upon this system the defense of the capital will be constructed. It should be said in connection with these experiments, that with the light charges and projectiles used the energy obtained from the 6-in. guns mounted in the turrets was greatly inferior to what might be expected from the siege guns of any first-class power.

It may be of interest to add that the last of the 18 iron-clad forts for the defense of the Roumanian capital is about completed. These forts are three miles apart, some 10 miles from the city, are in a circle nearly 50 miles in circumference, and are connected by a railroad, wagon roads and telegraph. The armament is of Krupp guns.

(TO BE CONTINUED.)

STEAM LANES ACROSS THE ATLANTIC.

By Lieutenant Henry H. Barroll, U. S. N.

In 1855 the principal ship-owners, underwriters and merchants of Boston addressed a letter to Lieutenant M. F. Maury, U. S. N., at that time in charge of the Naval Observatory, and asked that he would consider the adoption of separate routes or "lanes" across the Atlantic, between Europe and American ports North of Cape Hatteras, by following which lanes steamers might diminish the chances of collision.

Among the signers of this letter were Messrs. John S. Sleeper, C. W. Cartwright, J. Ingersoll Bowditch, and Mr. R. B. Forbes, the latter gentleman being accredited by Lieutenant Maury with having originated the idea of this system of routes.

Maury carefully studied the subject and made a comprehensive reply, accompanying it with maps, showing where, in his opinion, the lanes should be located.

In his investigation he consulted the log-books of the Collins (American) and Cunard (English) lines of steamers. He found that along that part of the route extending between the meridians of 15° W. and 65° W. the American vessels, in their voyages to and fro, made use from time to time of a breadth of ocean 300 miles in width, while that of the English line was only 150 miles. The American route overlapped and included that of the English vessels.

There was, consequently, a belt 300 miles wide extending between these longitudes, in any part of which a sailing vessel was either at night, or in a fog, liable to come in collision with a steamer; while steamers were also liable to collide with each other.

Maury's conclusions and suggestions were largely based upon the strength and direction of the prevailing winds and currents, which at that day bore a much more important part with regard to steam navigation than they do at present. A summary of his reply to the above-mentioned letter is as follows:

He suggested that there should be designated a "Lane" or band 20 or 25 miles in width near the northern boundary of this 300-mile strip, and another 15 or 20-mile band near the southern border, and recommended that easterly bound steamers agree to use the southern, and westerly bound steamers the northern of these routes. This would greatly diminish the chances of collisions, while it would not add materially to the length of the voyage. He plainly demonstrated that, by adhering as closely as possible to these routes, vessels would derive the most advantage from the set of the Gulf Stream on the eastern route, and avoid its resisting force when coming westward.

He advocated having these routes engraved upon the general charts of the Atlantic, thereby letting it be constantly apparent by a vessel's plotted position whether she was or was not in one of these lanes. If she were a steamer she would attempt to remain within these limits, while a sailing vessel, although possibly finding it convenient to use the lanes during clear weather or by daylight, could easily edge away at the approach of night or thick weather. If sailing vessels during night or in foggy weather found it to their interest to cross these lanes, they would do so as rapidly as possible, and while in these limits would know that all danger to be apprehended would be in one certain direction.

As all steamers in either route would be standing in the same direction, their chances of colliding with each other would be reduced to a minimum, and could only occur from gross carelessness.

Lanes any narrower than those which he proposed, he claimed, would be disadvantageous, owing to the difficulty that steamers would experience in keeping within them; on the other hand, a broader lane might lead to a want of vigilance, while it would occupy so much of the ocean that sailing vessels would object to keeping clear of it. The narrower the lane, to a certain extent, the more readily would sailing vessels keep clear of it, since they could the more quickly pass through it if occasion demanded this; while from its narrowness sailing vessels would know that the liability of meeting steamers in those limits would be greater than in a broader pathway.

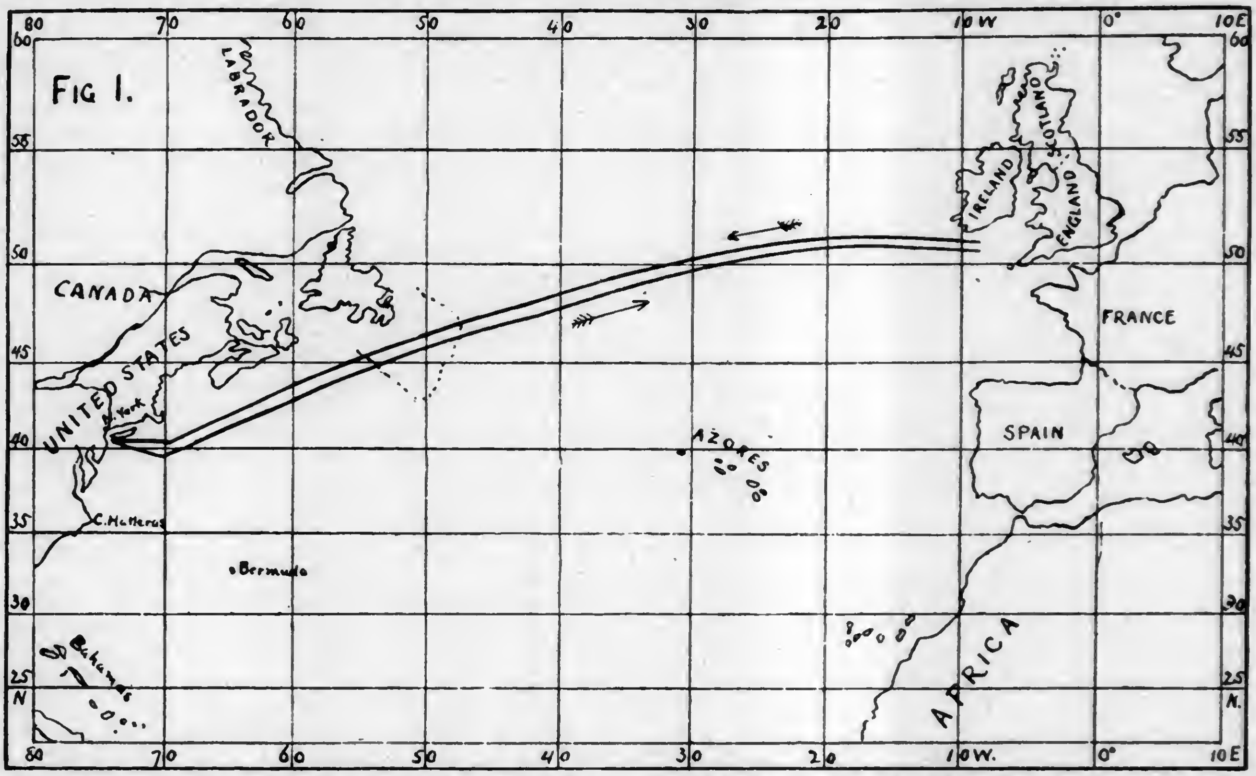
Much of the reply was devoted to a description of the Banks of Newfoundland, and showing how these shoal banks would assist masters of vessels, even in thick weather, in keeping within the designated lines. Lieutenant Maury says:

> You will observe by looking at this lane (fig. 1) that the Grand Banks afford a pretty good landmark, which can be used in the thickest weather. Generally the water thermometer is found to fall as soon as you near these banks. The eastern edge runs north and south, and therefore affords an excellent correction for longitude. Having ascertained by the lead when the vessel first strikes this edge, then noting the soundings and the distance run before clearing the Grand Bank, the latitude will also be known with accuracy sufficient to enable the navigator to decide whether he be in or out of the lane, and if out, on which side.
>
> The lane crosses the Banks near their greatest width, 275 miles. If a steamer be crossing there in a fog, and in doubt as to her position, she can judge by their breadth and the sounding pretty nearly as to the latitude. For instance, if the breadth of the Banks when crossed be less than 275 miles, but the soundings not less than 40 fathoms, the vessel has crossed the Banks to the north of the lane. But if she find herself in

less than 30 fathoms, then she has crossed to the south of it. Should she, however, find herself in water that suddenly shoals to less than 20 fathoms and as suddenly deepens again, then she is near the Virgin Rocks, or the rock and Nine Fathom Bank to the east of them, and her position is immediately known.

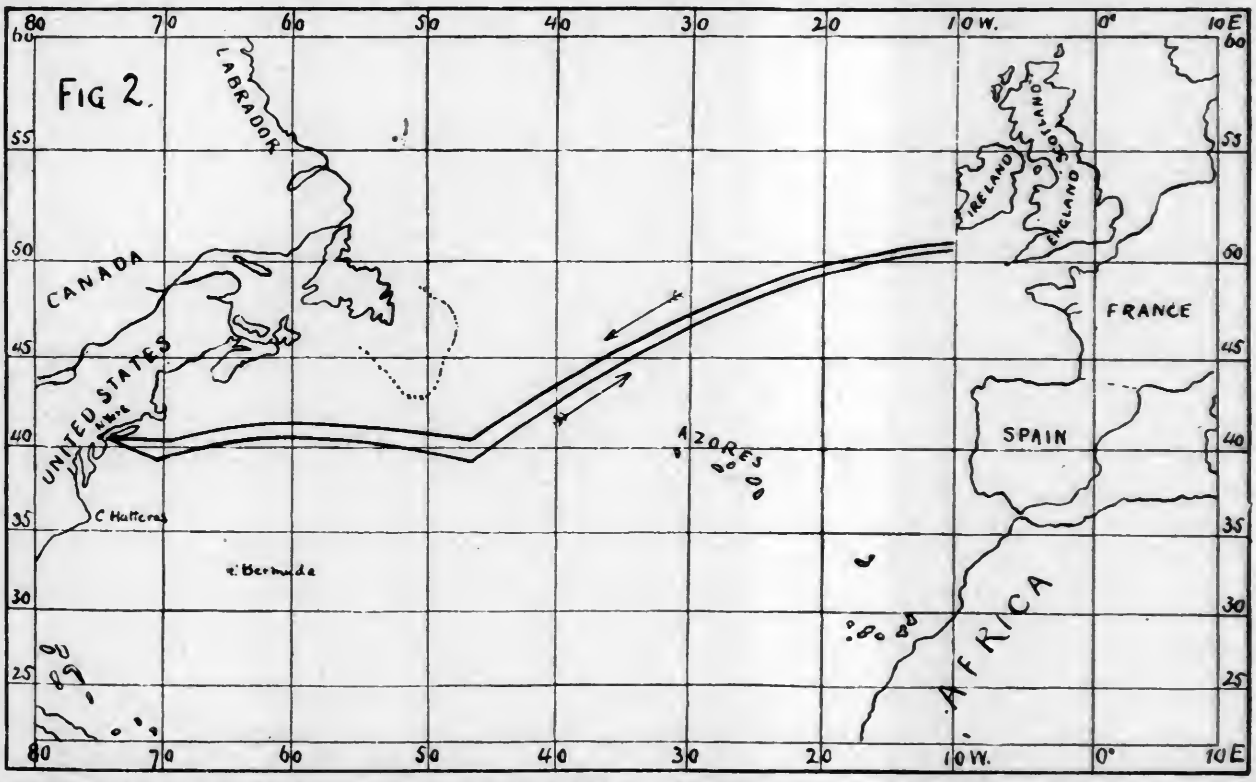
by steamers both going and coming; whereas, with the lanes that liability is incident to the steamers alone that are westerly bound, and the fishermen will have the advantage of knowing pretty nearly where the steamer will pass, and which way she will be coming.

And as for its being obstructed by ice, so as to compel the



It should be recollected, however, that these lanes are not channel-ways in which steamers must keep or be lost. Gales of wind, ice, and other things, will now and then force a steamer out of them, and in such cases she will be just where she is now, for she will then be in no more danger than at present.

steamers, as it occasionally will, especially in May or June, to turn out of it now and then, the Erie Canal of New York is obstructed by ice the whole of every winter, but that does not prove it to be of no value; it only shows that it, like this lane, would be of more value to commerce if it were never obstructed by ice or anything at all.



It may be urged against this lane that it cannot always be followed on account of the ice, and that inasmuch as it crosses the Grand Banks, the steamers that ply in it mav now and then run down a fishing vessel. The reply is, that as far as the fishermen are concerned, they are now liable to be run down

Although the routes, as recommended by Maury, and shown in fig. 1, are at certain months advantageous, yet we now know, in the light of later experience, that it is not expedient to pursue them during certain seasons of the year. The great danger to be apprehended is the collision

with icebergs, derelicts, or other vessels, while running through the fog-belt which is almost constantly found on the Newfoundland Banks during the ice season.

In the vicinity of Virgin Rocks and Flemish Cap, the cold Polar Current, bearing hundreds of icebergs broken from arctic glaciers, meets the warmer waters of the Gulf Stream. This difference in temperatures causes almost continuous fog, and, therefore, the Banks of Newfoundland are especially dangerous at such times.

Unfortunately, the shortest-distance route between New York, Boston or Philadelphia and European ports lies close to Cape Race, the southernmost point of Newfoundland, thus traversing the very heart of this fog-bank; while the demand for speedy transit precludes the idea of the more rapid steamers slowing down.

Indeed, it is claimed by some masters that there is advantage in running fast through fog, since it shortens the time during which a vessel is liable to collision, while the long vessels of the present day need plenty of speed to give them quick turning power.

In the last 30 years the improvement in the instruments for the navigating of ships, determination of the compass error, steam steering gear, etc., as well as the number of voyages that each commander has made over this particular course, enables the steering of the course to the nearest degree. It is, therefore, unnecessary that so wide a path should be designated as that when Lieutenant Maury, in 1855, submitted his answer to the gentlemen of Boston.

A number of the New York and English transatlantic companies have already of their own accord adopted separate routes to and fro, varying in latitude according to the season of the year, and the eastern and western routes of each line being separated from each other a distance depending upon the opinions of the commanding officers of each particular line.

These routes, seeking the shortest distance between the two hemispheres, naturally cover about the same belt of ocean; and with a little co operation among the several steamship lines which have already adopted separate routes, a single pair could be agreed upon that would be practically a steam lane across the Atlantic.

Although these lanes are not compulsory, yet they are adhered to to that extent by the above-mentioned steamship companies that, when the *City of Paris* recently encountered an accident to her machinery, and it was ascertained that she had drifted to the northward of the line of travel, an officer was despatched in an open boat to seek this line, and in a short time returned with assistance.

It must not be overlooked that this would be one of the most important advantages to be derived from the establishment of this one system of steam lanes—the certainty that in event of disaster the damaged vessel would be certain of speedy assistance from other steamers.

The routes even now taken by the principal lines very nearly coincide, being found by experience to be the safest and shortest routes. What is desired, therefore, is that, instead of the several lines adopting each a separate system of routes, they may agree upon one system. This need not be more than a certain line, provided that all shall agree to keep to the southward of that line on the eastern voyage, and to the northward of that line on the western voyage. But, in order to render the transatlantic routes safe in the ice season, this line should be traced during those months to pass well south of what has been shown by experience to be the lowest limit of icebergs.

This would add 100 per cent. to the safety of transatlantic travel, and would allow almost the same speed across the Atlantic as at present is made.

The difficulty in the way of laying down any compulsory system would rest in the fact that such a system could not be enforced, while if it were thought that such courses would cause advantage to one, and disadvantage to another port, the scheme would be opposed by the citizens of that port which was militated against.

Notwithstanding the discrimination, however, which might occur between ports situated on the same side of the Atlantic by this adoption of steam lanes, yet there could be no disadvantage to any one of the several lines running into the same port, New York, for example, in using such precaution, while it would greatly enhance the safety of the travelers, shippers and underwriters of that port.

It has been clearly proven that vessels which persistently use, during the ice season, that route which is known to be endangered by the presence of icebergs and fog-banks, sooner or later encounter disaster.

The number of vessels which have been damaged by ice in the North Atlantic would be startling. A partial list compiled by the United States Hydrographic Office, and showing some 60 vessels injured in some way by ice since 1882, gives an idea of the damage done to commerce by the presence of these dangers on the Newfoundland Banks.

Among the most recent of these may be mentioned the *Nessmore, Washington City, Mareca, Miranda, Minister Maybach, Tynedale, North Cambria, Thingvalla, Portia,* etc. The latter vessel was lifted up bodily while in mid-ocean by the toppling of a berg.

Of course there will be some conflict of opinion as regards the proper distance to be maintained, at different points along the lane, between the eastern-bound and western-bound vessels, at different seasons of the year. These opinions are based upon the personal experience of the several commanders of vessels of the various lines; and one commander *may* have had favorable voyages during certain months, along a track where another has continually encountered fogs, ice-fields and bad weather, at the same time of the year.

But masters of vessels are comparatively in accord as to the fact that certain routes are positively dangerous at certain seasons. The North Atlantic Pilot Chart, issued December 1, 1887, had engraven upon it separate routes to be taken by steamers to and from Europe. Since that time these lines have been produced upon each monthly chart, varying in location according to the probable position of the ice and fog-belts.

With regard to these lines, as laid down for those months when there is no danger to be apprehended from ice, I quote from the remarks of Lieutenant Everett Hayden, U. S. N., made on this subject before the United States Naval Institute:

Eastward bound.—Follow this track or nothing to the *northward* of it. Leaving New York, steer for latitude 40° 26′ N., and longitude 73° 46′ W. Thence E.S.E. ½ E., to the 100 fathom line, then deep soundings and off soundings, crossing 60° W. in 42° N. and 50° W. in 45° N., thence following the great circle, crossing 40° W. in 48° 01′ N., 30° W. in 49° 56′ N., 20° W. in 50° 55′ N. and 10° W. in 51° N.

Westward bound.—Follow this track or nothing to the *southward* of it. Cross 10° W. in 51° 10′ N., thence follow the great circle, crossing 20° W. in 51° 16′ N., 30° W. in 50° 28′ N., 40° W. in 48° 46′ N. and 50° W. in 46° N. Cross 60° W. in 43° N., 69° W. in 40° 38′ N., then keep inside 30 fathoms, steering to cross 74° W. in 40° 30′ N.

With the addition of a route from the English Channel (course about west by north), joining the west-bound route in about longitude 20° W., and the shifting of both routes to the southward during the ice season, this plan has been consistently and persistently recommended on the Pilot Chart, and many letters of approval have been received from practical navigators and others. The main feature of this plan, it will be noticed, is to *keep to the right* of a narrow central belt, whose limits are accurately defined both graphically and by means of a detailed printed description.

Westward-bound vessels are thus enabled to take advantage of the Labrador current, shaving Cape Race if they choose, and eastward-bound vessels can go as far south as they please to take advantage of the Gulf Stream and the easterly drift current in mid-ocean. At the same time in the central belt the danger to the fishing fleet and other vessels is at a minimum; to the north of this belt danger is to be looked for, principally from the east, and to the south of it, from the west.

Adherence to southerly routes in going eastward is certain to give reduced times of passage, while a more northerly European route, although shortening the distance, requires more care, slower speed, and is fraught with greater danger during the ice season, owing to the prevalence of fog.

In a letter on this subject to the Maritime Conference, recently held in Washington, Mr. C. A. Griscom, President of the International Navigation Company, says:

There can be no doubt that the risk of collision is the principal danger to be apprehended in the navigation of modern

steamships, and no one thing will contribute more to lessen this risk than the establishment of lane routes in the now already crowded North Atlantic.

My own view is that the lanes we have adopted are the most prudent, viz., to keep south of 42°, when crossing the meridian of 50°, from February 15 to August 15, and a safe distance south of the Virgins the rest of the year, separating the east-bound and west-bound tracks at the meridian of 50° about one degree.

While we pursue this practice with the steamers under our management—some 26—the good effect thereof is, of course, almost negative so far as the lane feature is concerned, because the practice is not general.

It would, in fact, be impossible to organize such a system of routes except voluntarily on the part of the steamship companies.

During the months of May and June especially a route further north than 41° N. latitude and 48° W. longitude, will sooner or later, owing to the fogs which here prevail, lead to collision with ice, derelicts, or other vessels.

There is very little gain in time compared to the great risk that the transatlantic mail has to undergo when following other than the safest route; the contract for carrying the mails should be given only to companies which guaranteed to follow at all times the safest, and not necessarily the speediest, route.

In regard to this subject Lieutenant Hayden says:

Another important element is the fact that the mails are given to the fastest vessels. One steamer may take a safer route, traverse a slightly longer distance, and lose the mail. This very thing happened only last year, when the *Werra* was beaten a few hours by the *Servia*, and Captain Bussius complained that he had followed the route recommended and lost the mail in consequence.

It is gratifying in the extreme, however, to be able to record that, notwithstanding the loss of the mail contract, the intelligent commander of the *Werra*, instead of being deterred from doing what he manifestly knew to be his duty, gives later to the Maritime Conference this expression of his opinion:

I would say that in the vicinity of Long Island, Nantucket and St. George's shoal grounds, I think it absolutely necessary to establish lanes for steamships apart. This can be done very easily, even if astronomic observations are not at hand, and the position of a ship is doubtful.

A westward-bound ship to keep north—that means, on 40 or 35 or 30 fathoms of water by soundings, when thick weather prevails. Here the ship will find pilots, as their position is in this line.

An eastward-bound ship ought to steer from Sandy Hook east by south, one quarter south, to the 90-fathom soundings, then east on deep soundings. This will cause steamers to go safely almost 50 degrees west, if the eastward-bound steamers keep warm water during summer, or, say, in latitude 41°. I have proved it dozens of times, that in summer a distance of 80 to 90 miles is gained eastward by the Gulf Stream between Sandy Hook and Scilly, if I kept well to the southward. I shall not fail to run these southern routes this summer.

It would be hard to find a more efficient class of men than the officers and crews of the transatlantic steamships. Much is expected of them by their companies, who have committed to their keeping millions of dollars' worth of property and thousands of lives; and it is due to their skill and untiring, unremitting vigilance, that the number of collisions are not yearly, thousands instead of dozens.

But of what avail is the greatest efficiency and the utmost vigilance, if at any time some towering iceberg looms up through the dense fog, at a distance of 500 yards, in front of an ocean greyhound going at the rate of 20 knots an hour?

A steamer of 10,000 tons, going at the rate of 20 knots per hour, would strike with an energy of about 40,000,000,000 foot-pounds, and there would not be enough of her left to make a horseshoe nail.

At present the great desire to lower the time of passage between Europe and America—to "break the record"—has a charm which few of the citizens of either hemisphere can resist.

Regardless of the danger to be encountered, and actuated by the desire to render a certain line, or even a particular ship, famous, masters will drive these splendid steamers through dense fog-banks, day and night, at a speed of 20 or 21 knots (24 or 25 miles) per hour, along a track known to be beset with thousands of dangers.

The great mass of travelers are ignorant of the fearful risks which surround them under such circumstances, and rest contented in the assurance that the greatest care will be taken. The vessel rushes madly along; well-trained eyes are continually strained to detect the first sign of danger, and all that can add to the security of the ship, so far as intelligence and watchfulness, on that course, is being exercised; but that she does not collide with some of the icebergs, derelicts or other vessels along the route is, in many cases, to be ascribed to good luck rather than carefulness. It is impossible to exercise care at such a rate of speed in thick weather. Choosing the shortest line between the two ports, she adheres as strictly as possible to this course, just as though she were the only vessel upon the ocean, regardless of the fact that this is also the shortest line for all other vessels.

The result is that she possibly "breaks the record," and arrives off Sandy Hook in six minutes less time than some other vessel has previously done the distance, or—perhaps she strikes an iceberg or derelict, in which case nothing is left of vessel, passengers or freight, except bills of lading, freight receipts and insurance policies.

Possibly some months later a boat may be picked up marked *Erin*, or a back-board, upon which is carved *City of Boston*; but such finds are not frequent.

Yet, such is the inconsistency of Human Nature, that while the intelligent American or European, knowing the immense risks, would shrink from sending his family by such a hazardous route, he is himself always ready to "take the chances," for the excitement of participating in one of these great ocean races.

It becomes, then, necessary for the companies to save us from ourselves. This they can only do by absolutely eschewing the dangerous routes. The race would be just as exciting, and fully as conclusive, if made over a less dangerous course. Indeed, instead of being a proof of the speed and excellence of the two vessels, it becomes in a great degree a question of the amount of nerve possessed by the two commanding officers.

I cite as a case in point the recent great race between the White Star steamer *Teutonic* and the Inman steamer *City of New York*, in which the former was victorious, making the passage from Queenstown to Sandy Hook Light-ship in 5 days, 19 hours and 5 minutes, thus lowering the existing record of "best time" by 13 minutes.

The distance traversed by the *Teutonic* was 2,806 knots, at an average speed of 20.1 knots (about 24 miles) per hour, for 139 hours. The *Teutonic* sailed from Queenstown on August 8; at 2.15 A.M. was abreast Roche's Point, and closely followed by the *City of New York*. The daily runs of the *Teutonic* were as follows:

1st day of 24 hours	473 knots.
2d " "	496 "
3d " "	512 "
4th " "	500 "
5th " "	485 "
6th day to finish	340 "
Total	2,806 knots.

In order for the *Teutonic* to have made this short route, she must have steamed directly across the Banks of Newfoundland, which, according to the above list of runs, she traversed at the rate of 500 knots per day, or 25 land miles per hour.

With regard to the danger that might be caused to the fishing fleet, owing to the establishment of regular lanes at that season, at which the said lanes ran through their fishing grounds, I can do no better than to quote again from Lieutenant Hayden on this subject:

When we consider, however, the enormous importance of transatlantic steam navigation, the demand for great speed and quick passages, the fact that the shortest route is close to Cape Race, that storms, fogs and ocean-currents enter as a factor less and less every year, that a single great ocean steamship, carrying the transatlantic mail, and straining every nerve to lessen the gap that separates the Old World from the New represents almost, if not quite, as great a value in number of

lives and amount of property as the entire fishing fleet of every nationality, I must say it seems to me that all other interests are necessarily subordinate, and any regulations likely to be effective must be framed accordingly.

The best way to insure any such reform in the present practical century is to show that it will pay; and the most convincing argument that could be brought to bear upon those vessel owners who would persist in following the ice-laden path, would be the loss of freights and passengers, or higher rates of insurance by this route during the dangerous season of the year.

If it were more generally understood by travelers, shippers and underwriters, that in patronizing those vessels which, in defiance of all that experience and common sense suggests, still continued to go over the most unreliable course, then the loss of steady passenger traffic and the increased rate of insurance would probably have the effect of turning into the recognized safe routes all of the obstreperous vessels.

UNITED STATES NAVAL PROGRESS.

THE trial trip of the new cruiser *San Francisco* took place in the Santa Barbara Channel, off the coast of California, August 27, a run of four consecutive hours being made. The preliminary report stated that the ship made the first run of 40 miles in 2 hours, 1 minute, 13 seconds, making an average speed of 19.8 knots per hour. After turning she then ran over the course again, making the 40 miles in 2 hours, 4 minutes, 44 seconds. The time for the whole run was thus 4 hours, 5 minutes, 57 seconds, giving an average speed of 19.57 knots per hour. During a portion of the time the speed ran up to 20.06 knots. It is understood that the correct speed, after making all proper adoptions, will be about 19.70 knots per hour, in which case the *San Francisco* will earn a considerable premium for her builders, as the contract speed was 19 knots, with a premium of $50,000 for each additional quarter knot.

This result makes the *San Francisco* at least the equal of the *Baltimore* and the *Philadelphia*, built in the East.

The *San Francisco* has already been described and illustrated in previous numbers of the JOURNAL. She was designed in the Navy Department, and built at the Union Iron Works, San Francisco. The general dimensions of the ship are: Length, 310 ft.; breadth, 49 ft.; mean draft, 18 ft. 9 in.; displacement, 4,083 tons. She is unarmored, with the exception of a protective deck. The engines were designed in the Bureau of Steam Engineering. There are two direct-acting, vertical, triple-expansion engines, one to each screw, the cylinders being 42 in., 60 in. and 94 in. in diameter and 42 in. stroke, the working pressure being 135 lbs. There are four double-ended boilers 14 ft. 6 in. in diameter and 19 ft. 2 in. long.

The ship will carry twelve 6-in. breech-loading rifles, with a strong secondary battery of rapid-fire and machine guns, and several torpedo tubes.

The *San Francisco* is of the same general type as the *Philadelphia* and *Baltimore*, and, like those ships, promises to be a very handsome and effective cruiser.

THE NORFOLK NAVY YARD.

The Norfolk Navy Yard, under the wise policy pursued by the Navy Department, has been of late years made one of the two great building yards on the Atlantic Coast, being second in importance only to the New York Yard. Norfolk has always been noted for the excellence of its work, and the yard is supplied with an excellent plant both in the plate and the machine shops, though some additions are still needed. The work now in progress makes an excellent showing and the yard is an exceedingly busy place.

Besides a number of vessels under repair, two of the ships of the new Navy are under construction. One of these is Cruiser No. 8, one of the two 3,000-ton cruisers, the other one being at the New York Yard. This ship has made fair progress and begins to show her fine lines already, as the framing and plates go into place. These ships were recently described in the JOURNAL.

The other ship is the *Texas*, the first battle-ship of the Navy. While not so far advanced as the *Maine*—chiefly on account of delay in delivering the steel—this ship has made excellent progress. The framing for the armored deck is in place, most of the lower plating on, and the hull is rapidly assuming shape.

The *Texas* is 290 ft. long, 64 ft. in breadth, 39 ft. 8 in. moulded depth, 22 ft. 6 in. mean draft and 6,300 tons displacement. The hull is built on the cellular double-bottom system. She will have a belt of steel armor extending from 2 ft. above the water line to 4 ft. 6 in. below, while the engines, boilers and magazines will be protected by 12-in. steel-faced armor extending along the sides for 100 ft. and closed at each end by transverse bulkheads 6 in. thick. This armor has 6-in. hardwood backing. The protective deck, 3 in. thick, slopes forward to the point of the ram, 10 ft. below the water-line and aft far enough to cover the steering gear. The main deck carries a redoubt with 12-in. steel armor, in which are the bases of the two turrets, also of 12-in. steel. The conning-tower is of 12-in. steel, and the connections for the steering gear are protected by steel tubes 3 in. thick, while the ammunition hoists are protected by 6-in. steel.

Each turret will carry a 12-in. breech-loading rifle; these guns will each have a complete broadside range, with an additional range of 40° for the forward and 60° for the after gun. There will be also six 6-in. guns; four of these will be in sponsons on the main deck, two of them training from right forward to 25° abaft the beam, and two from right astern to 25° forward of the beam. Of the other two one is mounted forward and the other aft, each having a train of 120°.

The secondary battery of the *Texas* will include four 6-pdr., six 3-pdr. and two 1-pdr. Hotchkiss guns; four 47-mm. and four 37-mm. revolving cannon and four Gatling guns. She will have two military masts, each carrying two machine guns in the top. She will carry a steam launch and steam cutter, each armed with a 3-pdr. rapid-fire gun, and will also carry two second-class torpedo boats on her upper deck. She will be provided with six torpedo-tubes, one forward, one aft and four in broadside.

The ship will have a full electric light plant. The ordinary provision of ammunition will weigh about 170 tons for the large guns and 72 tons for the secondary battery. The coal bunkers will hold 500 tons, and 450 tons more can be carried in the angle above the protective deck.

The engines of the *Texas* are under construction at the Richmond Locomotive Works, and are referred to on another page.

One of the features of the Norfolk Yard is the new Simpson dry dock. This dock is entirely of timber; briefly described, the floor rests on piles driven down in regular rows, 4 ft. apart longitudinally and 3 ft. transversely. Under the keel-blocks, which bear the weight of the ship, four additional rows of piles are driven. On the piles are laid longitudinal rows of heavy pine timbers crossed by similar transverse timbers. Portland cement is filled in about the heads of the piles and up to the floor, which is of heavy Georgia pine timbers. The sides and end rise at an angle of 45° in steps or altars supported by piles; as the sides are built up they are backed by puddled clay carefully rammed in. All the timber above water is creosoted.

The gate of the dock is an iron caisson, held in place by the pressure of the water and kept tight by heavy rubber packing, extending the whole length of the keel and stern.

This dock is 530 ft. long over all; 500 ft. long inside the caisson; 130 ft. wide on top amidships; 50 ft. wide on the floor; 53 ft. wide at entrance, at the bottom, and 85 ft. at top. The gate-sill is 30½ ft. below the coping and 25½ feet below high water. It will take in the largest ship now under construction for the Navy.

The dock can be flooded by culverts opening directly through the caisson. It holds about 7,000,000 gallons of water, and can be emptied in 90 minutes by two centrifugal pumps each driven by a vertical engine with 28-in. × 24-in. cylinder.

It may be noted here that this dock cost $500,000, while the stone dock at the New York Yard, only 350 ft. in length, cost $2,241,000 to build, besides a large sum yearly for repairs. The first dock on the Simpson plan was built at East Boston in 1853, and is still in excellent condition.

A NEW VARIABLE BLAST NOZZLE.

THE accompanying illustrations—from *Engineering*—show a variable blast nozzle, invented and introduced in England by Messrs. Charles Adams, of London, and George Macallan, Manager of the Great Eastern Railway shops at Stratford. It is claimed that this nozzle is free from many of the defects charged against previous devices of the same class.

In the illustration figs. 1–6 show three different forms of this device; figs. 7 and 8 are perspective views of two different patterns, while fig. 9 shows the arrangement for modifying the size of the maximum opening.

standard size, while the main part of the blast pipe *b* terminates in an aperture of larger size. In fig. 1 the cap is shown closed down on the top of the blast pipe, being held firmly in position by a clamping screw which grips the rod by which the nozzle is worked, this rod extending to the foot-plate. In fig. 2 the cap is shown raised, thus leaving the larger orifice available for the discharge of the steam. As will be seen from fig. 7, the cap when thus raised is very accessible for cleaning.

In figs. 3 and 4 is shown a modified arrangement in which two caps *c d* of different diameters are provided, either cap being placed on the top of the blast pipe at pleasure. This arrangement has the advantage that, by

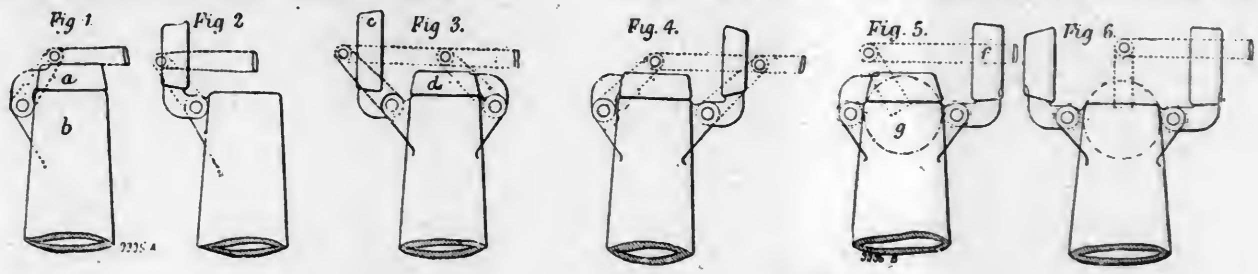


Fig. 7

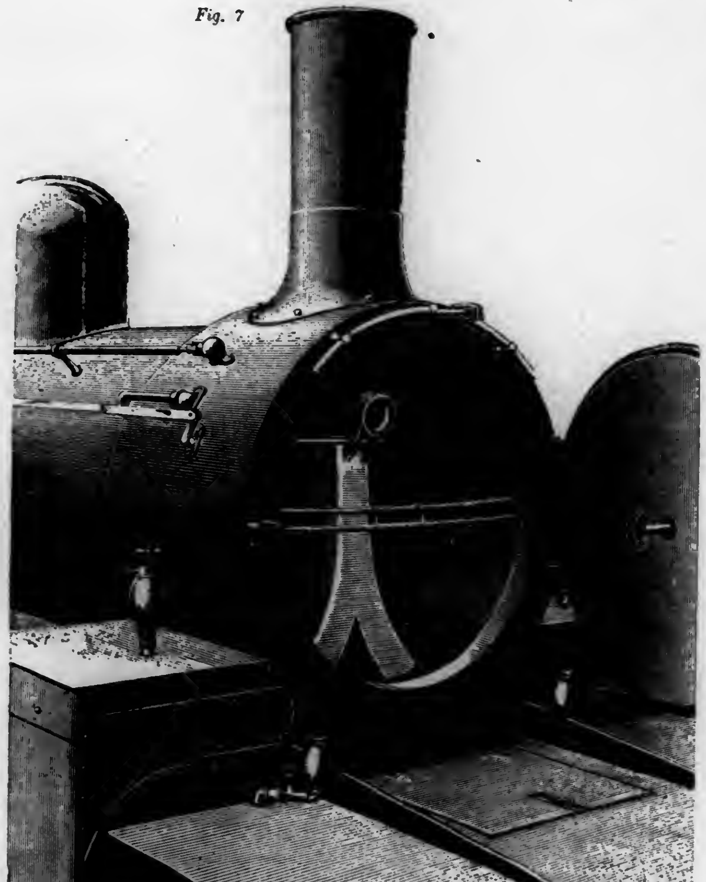


Fig. 8.

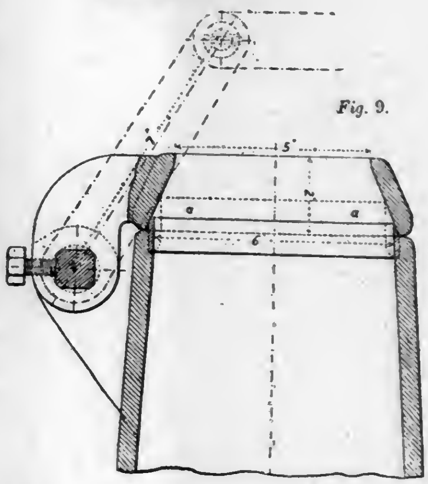


Fig. 9.

VARIABLE BLAST NOZZLE.

It is evident that, so long as a nozzle of invariable aperture is used, the dimensions of this nozzle must be fixed by a consideration of the hardest work which the engine has to perform, and whenever there is a less demand upon the steaming powers of the boiler the draft through the fire has to be controlled by closing the ashpan damper, by admitting an excess of air through the fire-box, or by a combination of these two means. In the device we now illustrate the standard aperture of blast nozzle is retained, but instead of this nozzle being fixed to the blast pipe, it is made in the form of a hinged cap, which can be readily lifted off, leaving a larger opening. Thus, in figs. 1 and 2, which show the form of the device which has been hitherto chiefly used, *a* is the cap, which has an orifice of the

making the caps of different depths each diameter of nozzle can be made to stand when in use at that height in the smoke-box which gives the best results, the height at which a blast nozzle is placed having, as is well known, a material effect on the draft produced. Another modification, of a similar character to that last mentioned, is shown by figs. 5 and 6, and in perspective by fig. 8, the two caps, *f g*, being in this case operated by a pair of partial pinions which gear intermittently into an intermediate wheel as shown, this wheel having teeth on part of its circumference only. In fig. 8 this gear is shown close to the blast pipe, it having been mounted thus for convenience in photographing; in reality, however, it is placed outside the smoke-box.

Fig. 9 is a section of the upper end of the blast pipe, fitted with Mr. Macallan's blast nozzle, and shows the provision made for varying the maximum area, the end of the fixed blast pipe having inserted in it a bush, the bore of which can be readily modified. Thus the dotted lines *a a* show a bush with a smaller aperture than that represented in full lines. Thus, for a particular engine, the maximum area of discharge permitted when the cap is lifted can be readily adjusted to suit the requirements of the case.

We have said that the normal area of a locomotive blast pipe is fixed by a consideration of the heaviest work to be done; but it will be readily understood that the occasion in which such maximum demands are made upon an engine constitute but a very small proportion of its working life. Had it not been that the ordinary blast pipe is to some extent an automatically adjusting contrivance—that is, to say, that when less steam is being used its action is less violent, and *vice versa*—the use of variable blast nozzles would long ago have become a necessity. But, even as it is, this adjustment is very imperfect, although its imperfection is far from being generally realized. Few, indeed, except those who have actually tried the experiment, are aware for what a large proportion of the working day a blast nozzle very considerably greater in area than the normal size is amply sufficient for a locomotive engaged on general service. It is this condition of things which Mr. Macallan's blast nozzle is intended to meet, by enabling a driver to work with a very moderate blast at all times when such a blast will suffice, thus not only avoiding waste of fuel, but also reducing the back pressure in the cylinders.

Up to the present time 60 locomotives on railroads running out of London have been fitted with the arrangement of blast pipe above described, and some of these engines have now been working upward of twelve months and with highly satisfactory results. The blast nozzle area, with the movable cap lifted, varies in these engines from 30 per cent. to, in some cases, as much as 77 per cent. in excess of the normal area. In the case of locomotives working main line passenger and freight trains, it is found that three-fourths of the time the engines do their work readily with the cap raised, the nozzle area being then generally about 30 per cent. in excess of the normal area. In the case of engines working heavy suburban traffic three-fourths of the work is also done with the cap raised, the nozzle in this case averaging about 40 per cent. larger in area than the ordinary orifice. The saving of fuel in engines fitted with this variable nozzle has been found to range from 10 to 15 per cent., the engines also running more freely with the cap raised, while there is less wear and tear of fire-boxes and tubes and less tube leakage. In the case of engines worked at different times, with different qualities of coal also, the arrangement gives a ready means of adjusting the draft to the requirements of the fuel.

The nozzle we have been describing has so far only been used on locomotives, but it is equally applicable to portable and traction engines, and on the latter class of engines especially, it would, we consider, be exceedingly useful. Our illustrations also only show the arrangement as applied to an ordinary blast pipe, but it is evidently equally applicable to vortex blast pipes or other modifications of the usual form.

THE RICHMOND LOCOMOTIVE WORKS.

The Richmond Locomotive works in Richmond, Va., had their origin in a shop engaged in building portable and stationary engines, saw-mills and similar work, to which was added later the construction of small locomotives for logging railroads. Some time ago the company was re-organized and shops were built on the outskirts of Richmond which in size, equipment and character of the work turned out will stand comparison with any of the older locomotive shops.

The buildings include a large foundry, smith shop, boiler shop, machine shops, erecting shop, wood-working shop, paint shop and the usual smaller buildings, such as pattern room, storehouse, etc. The erecting shop is 143 × 300 ft. in size, and is provided with an overhead traveling crane which is capable of lifting the largest locomotive and moving it to any part of the building. A transfer table with the necessary tracks connects the different shops and provides for the easy handling of work.

The plant includes many fine tools of large size, such as hydraulic riveters and flanging machines; frame planers; wheel-lathes, etc., and a number of tools specially designed for locomotive work.

The character of the work done can best be shown by a brief statement of the work now in progress and recently turned out, which includes 15 consolidation engines with 20 × 24-in. cylinders, for the Richmond & Danville; 2 consolidation engines with 21 × 24-in. cylinders and Belpaire fire-boxes, for the Chesapeake & Ohio; three 19 × 24-in. mogul freight and two 17 × 24-in. passenger engines for the Florida Central & Peninsular; one 17 × 24-in. passenger engine for the Greenfield & Northern, two of the same size for the Atlantic & North Carolina and one for the Atlantic & Danville; one 18 × 24-in. passenger engine for the Raleigh & Gaston; one 18 × 26-in. mogul engine for fast freight or heavy passenger service on the Richmond, Fredericksburg & Potomac; one 14 × 20-in. mogul engine for the Aberdeen & West End, and one of the same size for the Southwestern Arkansas & Indian Territory Railroad.

There are also under construction some logging locomotives and some stationary engines and creosoting machinery. The chief work of the shops, however, is and will be the building of locomotives.

The capacity of these shops is also shown by the fact that they have contracted to build the engines and boilers of the battle-ship *Texas*, now under construction at the Norfolk Navy Yard. This work includes two triple-expansion engines with cylinders 36 in., 51 in. and 78 in. in diameter and 39 in. stroke, with condensers, pumps and all other appurtenances, and four double-ended boilers 14 ft. diameter and 17 ft. long.

The work on these engines is now well advanced and they will be ready probably before the ship is. All of it has been done in the shops, the large cylinders being cast successfully in the foundry. Several of these cylinders are now being bored and turned in the machine shop, and a large part of the smaller work on the valves and condensers is completed.

The flanging and bending of the 1¼-in. plate for the boilers is a very interesting operation, and has been very successfully done. The boilers are beginning to assume their shape, and the work is making rapid progress. The fact that the work on these large boilers has been quickly and well done, and that the other work for the *Texas* has been handled without difficulty, shows the capacity of the shops.

The accompanying illustration shows a fine consolidation locomotive built for the Richmond & Danville Railroad—one of an order of 15. This engine has cylinders 20 in. in diameter with 24 in. stroke, and 50-in. driving-wheels. The driving-wheel base is 14 ft. and the total wheel base 21 ft. 6 in. The weight is 118,000 lbs., of which 104,000 lbs. are on the drivers.

The boiler, of steel ½ in. thick, is 60 in. diameter of barrel; the fire-box is 102⅝ × 41⅞ in. inside. The tubes are 2¼ in. diameter and 12 ft. 10¼ in. long.

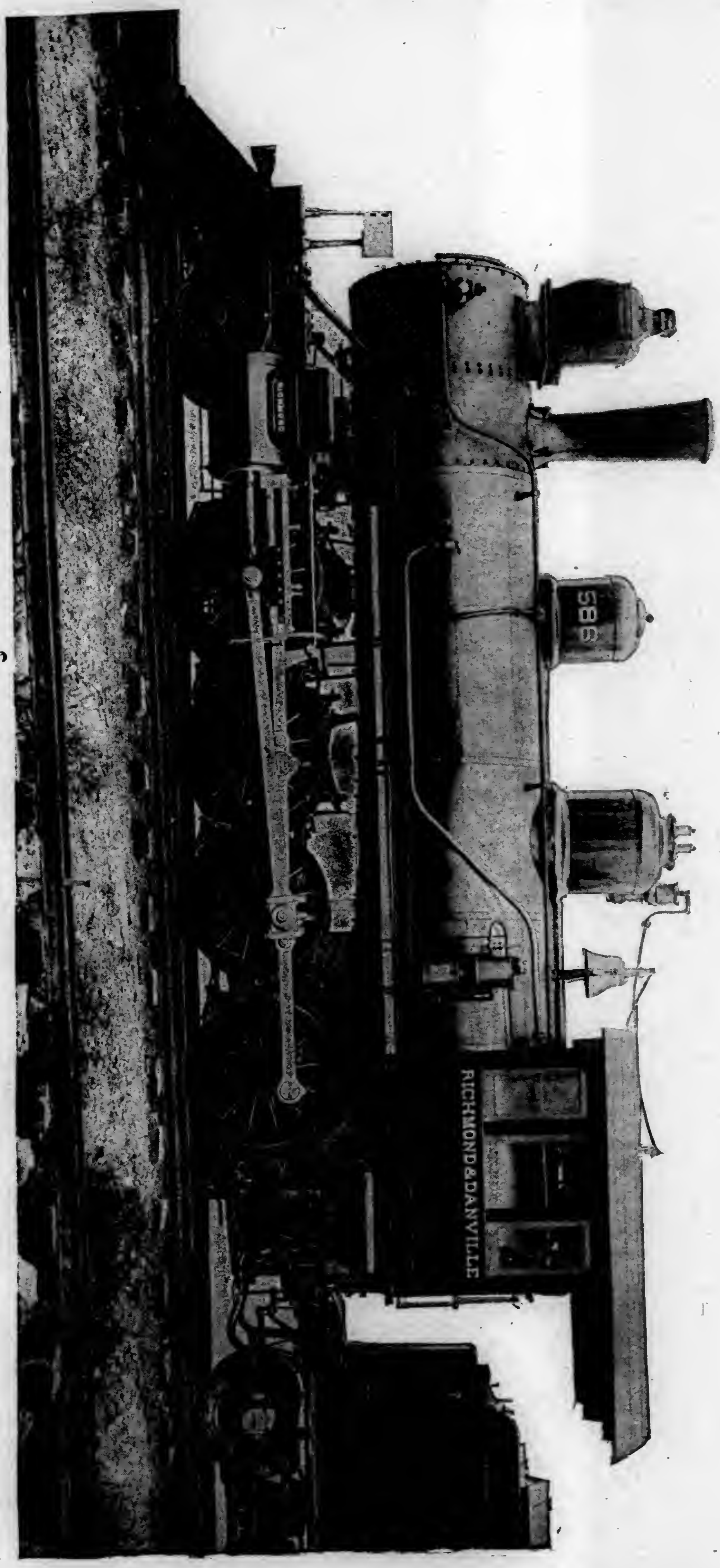
The main frames are 4 in. wide and 3½ in. deep. The driving-wheel tires are 3 in. thick, and the second and third pair are plain, without flanges. The driving axles are of steel, the journals being 7½ in. diameter and 8½ in. long. The driving-box brasses are of phosphor-bronze. The side-rods are of steel, with solid ends, provided with phosphor-bronze bushes.

The two-wheel truck has 30-in. steel-tired wheels; the truck axle has journals 5⅝ in. diameter and 10 in. long.

The cylinders, as already noted, are 20 × 24 in. They are provided with the Richardson-Allen balanced valves; the valve motion is of the ordinary shifting link type.

Space prevents the publication of the specifications in full. These engines are excellent examples of the latest practice, and ought to do good service.

The tender tank holds 3,300 gals. The tender has brakes on both trucks, and the engine is also provided with driver-brakes.



CONSOLIDATION LOCOMOTIVE FOR THE RICHMOND & DANVILLE RAILROAD.

BUILT BY THE RICHMOND LOCOMOTIVE WORKS, RICHMOND, VA.

THE ESSENTIALS OF MECHANICAL DRAWING.

By M. N. Forney.

(*Continued from page 422.*)

CHAPTER VI.

SCREW THREADS.

No description of an ordinary screw and nut is needed, excepting to point out that the threads of screws are of different forms and proportions, and that nearly all those which are commonly used have what are called "*right-handed*" *threads*, that is, the threads wind around the bolt, so that when looking at the end of a bolt the nut must be turned in the same direction that the hands of clocks or watches turn, to screw it on, and it must be turned the reverse way to unscrew it. The thread of what are called *left-handed screws* wind around the bolts in the reverse direction to those which are right-handed, and consequently the nuts must be turned in an opposite direction in screwing them on and off their bolts. For the present only right-handed screws will be considered.

In the construction and use of machinery and other metal structures it is of the utmost importance that all screws and nuts which are of a given nominal diameter should be *interchangeable*—that is, that any screw of, say, ¾ in. outside diameter, should fit any nut which is supposed to be of the same internal diameter. To do this their diameters must be *exactly* alike, the form of the threads must be the same, and the distance the threads advance in winding around the bolt or their *pitch* must be the same. It should be mentioned here, perhaps, that all screws commonly used are what are called *single threaded*, that is, they each have a single thread instead of two or more. If we take a string and wind it around a pencil in the form of a spiral, it will represent a single-threaded screw, and if we wound two or three threads alongside of each other, they would represent double or treble-threaded screws. These latter kinds are so seldom used that they will not be considered further.

Until a few years ago the most common form of the threads of screws was what is known as the V thread, represented in fig. 161. This was made sharp at the top and bottom, with sides which stood on an angle of about 60° with each other, as indicated in the figure referred to. The pitch of the threads, or, as it is commonly expressed, the number of threads to an inch, of bolts of the same diameter, formerly varied a good deal in different places and in screws made in various shops. In 1864 the inconvenience and confusion from this cause became so great that it attracted the attention of the Franklin Institute of Philadelphia, and a committee was appointed by that association to investigate and report on the subject. That committee recommended the adoption of the Sellers system of screw-threads and bolts, which was devised by Mr. William Sellers, of Philadelphia. This same system was subsequently adopted as the standard by both the Army and Navy Departments of the United States, and then by the Master Mechanics' and Master Car Builders' Associations, so that it may now be regarded, and in fact is often called the United States standard, but the design is due to Mr. Sellers, and the system should be designated by his name.*

Before describing the Sellers system of screw threads an explanation will be given of the method of drawing an old-fashioned V thread represented in fig. 161. A bolt 2 in. in diameter has been selected so that the drawing will not be too minute for the learner's hands and eyes. The number of threads is 4½ to an inch, or a pitch of $\frac{2}{9}$ in., and the angle between the sides of the threads 60°, as shown between 4′ and 5′. To draw such a screw, lay down the usual center line and the outline *a b c d* of the bolt or bar. In order to have an even number of divisions lay off a distance *b q*=2 in. Then with spring dividers subdivide this space into nine equal parts. With the 30° side of a triangle draw from the points of subdivision the lines *b e* 1*e*, 1*e*′, 2*e*′, 2*e*″, etc., which will represent the outline of the thread on one side of the bolt. In winding completely around the bolt the thread 1 advances lengthwise from 1 to 2. In a half revolution, or from 1 to 1′, it advances half that distance. Consequently the point of the thread at 1′ should be opposite its root at *e*′. If lines are drawn from the roots *e*, *e*′, *e*″, *e*‴, etc., of the thread and perpendicular to the center line of the screw or bolt and intersecting *c d*, as shown at 1′, 2′ and 3′, the intersections will be the positions of the points of the thread on that side of the screw and the sides of the thread can be drawn from those points, as explained.

The lines 1 1′, 2 2′, etc., which show the points of the thread as it passes from one side of the bolt to the other, would, if correctly represented, be curves. As already explained, it is a somewhat difficult problem to draw them correctly. The method of doing this will be explained farther on. For nearly all practical purposes, however, the point of the thread may be shown by straight lines, as in the figure under consideration. These lines should be drawn from the points 1, 2, 3, etc., on one side of the bolt, to 1′, 2′, 3′, etc., on the opposite side. In doing this care must be taken to get the direction of their inclination right, because if they are inclined in the opposite way from that shown in the engraving it would represent a left-hand screw. The lines 1 1′, 2 2′, 3 3′, etc., drawn from the points on one side of the bolt to those on the other will thus represent a *projection*, as it is called, of the point of the thread. Other lines *e f*, *e*′ *f*′, *e*″, *f*″, etc., drawn to connect the roots of the thread on opposite sides, will complete the representation of the screw. It will be noticed that the lines which show the points and those which show the roots are not exactly parallel to each other.

It was found that when V-shaped threads of the form shown in fig. 161 were used that their sharp edges were liable to injury, while at the same time the sharp points of the thread added very little strength to it. For this reason, when Mr. Sellers designed the standard thread which bears his name, he made the outer edge and also the root of the thread flat, as shown in fig. 162, and also in fig. 164. The latter engraving represents a section of the Sellers thread, which, for the sake of clearness, is drawn to a scale four times that of fig. 162, or four times the actual size.

The angle between the sides of the Sellers standard thread was fixed at 60°. To lay out such a thread, lay off the pitch *a b*, fig. 164, on a line *o o*′, and from *a* and *b* draw lines *a f*, *a f*′, *b f*′ and *b f*″ at angles of 60° to each other. These will form the outline of a V thread. Then subdivide one of the sides, as *a f*′ into eight equal parts, and draw lines 1 1′, 2 2′, 3 3′, etc., through the points of subdivision and parallel to *o o*′. Take off the parts *e*, *e*′ included between the parallel lines o o′ and 1 1′ from the point of the thread and fill in the parts *c*, *c*′, *c*″, included between the lines 7 7′, and 8 8′, at the bottom or root of the thread, as indicated by the shading. Then the width of the flat top and bottom measured parallel with the axis or center line of the screw will be equal to one-eighth of the pitch, and the diameter *d* of the bolt measured at the root of the thread can be calculated by dividing 1,299 by the number of threads to an inch and deducting the quotient from *D*, the outside diameter of the screw. It will be seen that the strength of the bolt is materially increased by filling in at the root of the thread.

The proportions of the Sellers system of screw threads for bolts of different diameters, and also the proportions of bolt-heads and nuts, of the same system, are given in the accompanying table.

To draw a Sellers thread we will take a bolt 2 in. in diameter, fig. 162. The pitch of the threads is again laid off on a line *a b* as before. Then from the table take the width of the flat portion of the thread, and set this off from the points of subdivision on *a b*, either above or below them. Then from the points thus laid down draw the sides of the thread, as in fig. 161. Complete the V shape of the point of one of the threads. With spring dividers measure the distance of the point of intersection of the two sides of the thread from *a b*, and lay off this same dimension at *e*″, the root of the thread, and draw *g h*, which will form the bottom of the spaces between the threads. Draw the outlines of the threads on the line *d c* opposite the spaces on *a b*, as in fig. 161. The diagonal lines 1 1′, 2 2′, 3 3′, etc., which represent the outer edges of the thread, may then be drawn, and also *e f*, *e*′ *f*′, *e*″ *f*″, etc., which represent the roots of the thread. Each pair of the lines which represent the outer corners, and those which show the root, will be parallel to each other, but as in fig. 161, the lines at the root and those at the point will not be exactly parallel, as the learner will observe if he lays down all the dimensions of the thread precisely.*

In doing this he will have found out how very difficult it is to draw a thread of this kind with sufficient precision, so that it will not appear more or less distorted, and if he should attempt to do it on a reduced scale, or to draw a smaller sized bolt, he will find that the difficulty increases with the reduction in the scale and size of the bolt. For this reason an easier method is usually employed in practice, which saves much time, labor and pains, and for most practical purposes answers as well as that which has been described. A bolt is drawn as in fig. 165.

* "Catechism of the Locomotive," by M. N. Forney.

* The fine lines *a b*, *g h*, and *d c*, in figs. 161 and 162 and at 1′, 2′, 3′ in fig. 161, are intended to represent pencil lines, and should be rubbed out after the drawing is completed.

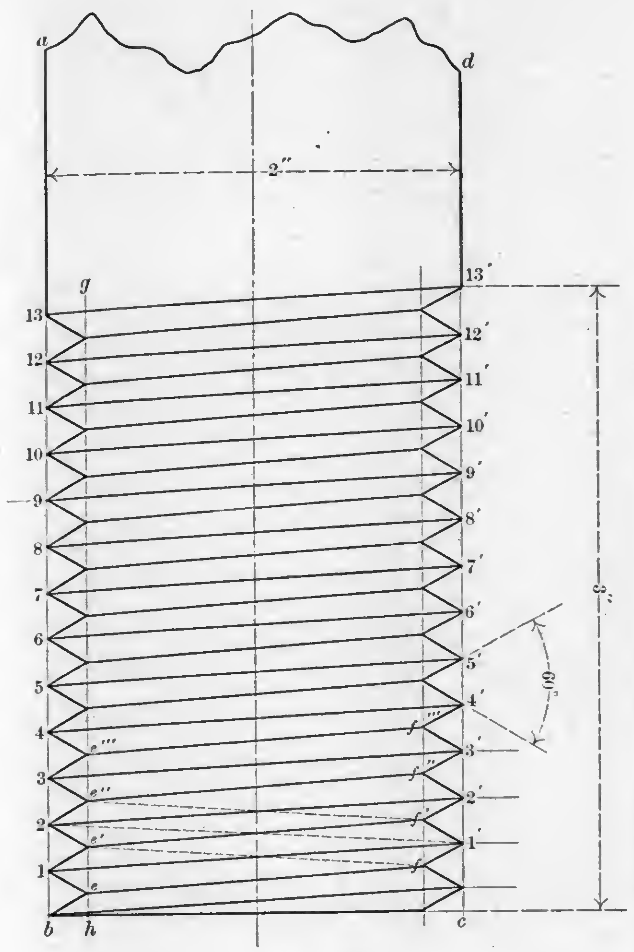


Fig. 161.

2-INCH SCREW: FULL SIZE.

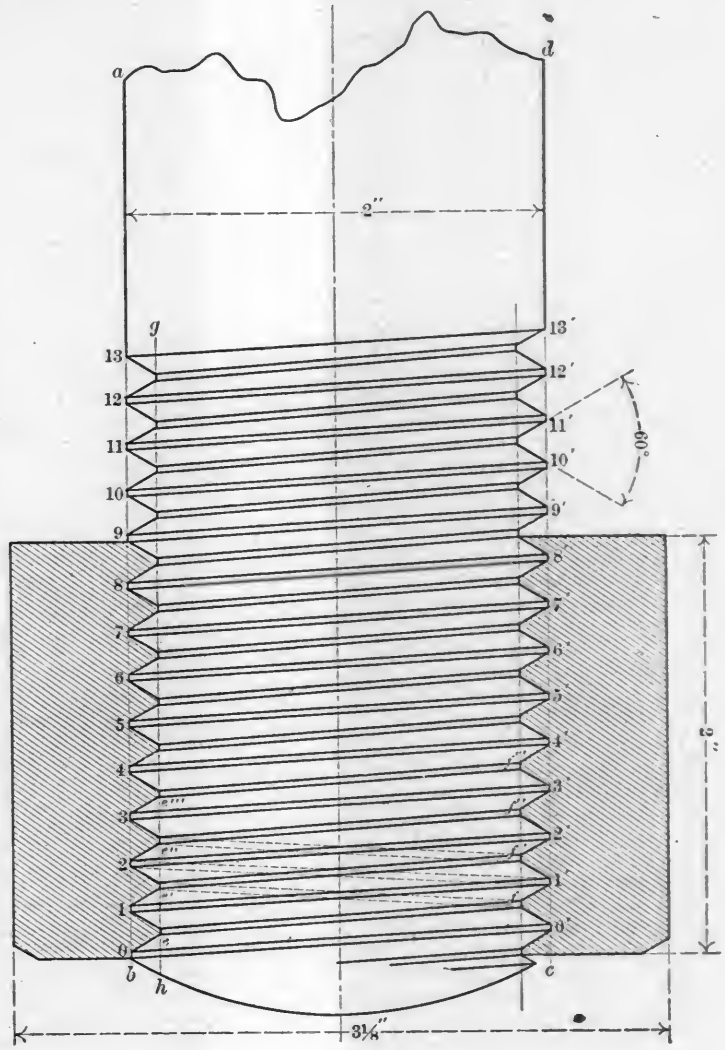


Fig. 162.

2-INCH SCREW AND NUT: FULL SIZE.

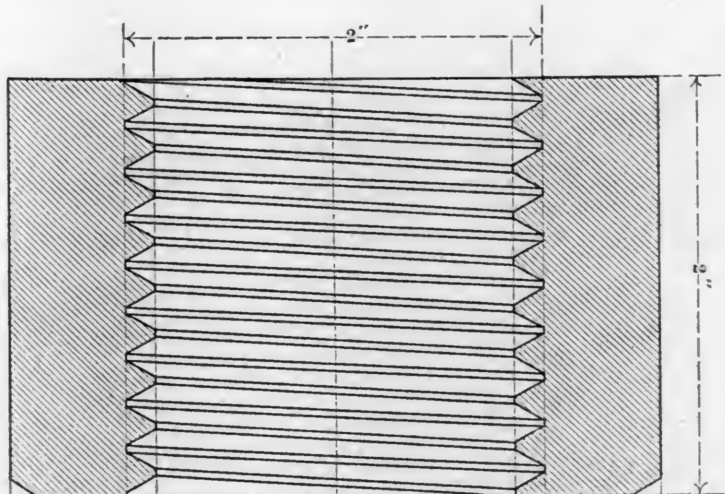


Fig. 163.

SECTION OF 2-INCH NUT: FULL SIZE.

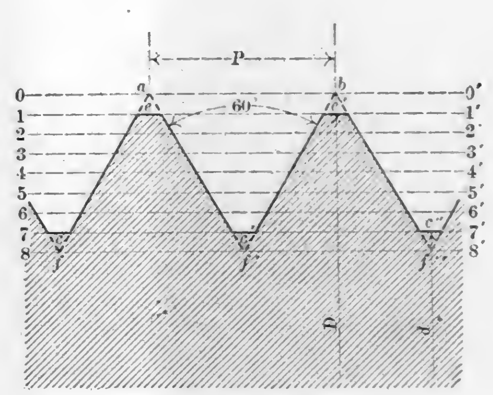


Fig. 164.

SECTION OF SCREW-THREAD: FOUR TIMES FULL SIZE.

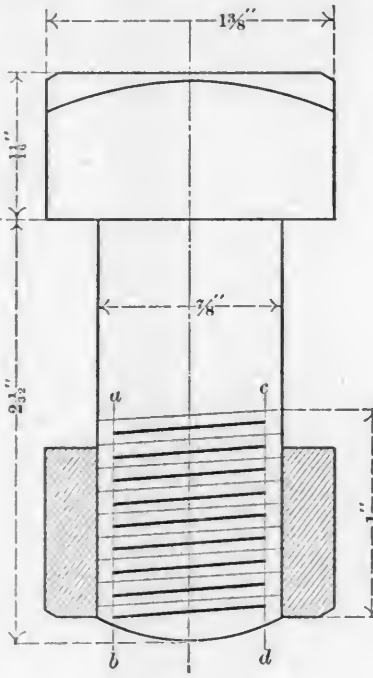


Fig. 165.

1⅜-INCH BOLT AND NUT: FULL SIZE.

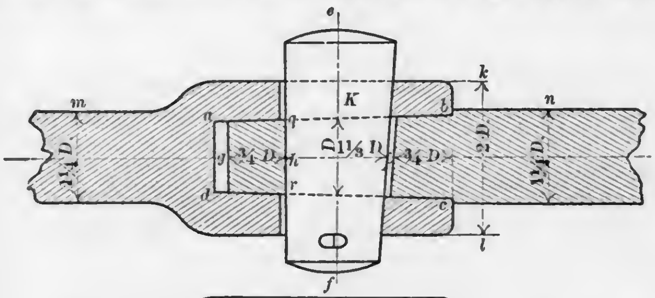
PROPORTIONS FOR SELLER'S U.S. OR FRANKLIN INSTITUTE. STANDARD							
SCREW THREADS.				NUTS.		BOLT HEADS.	
D = OUTSIDE DIAMETER OF SCREW.	N = NUMBER OF THREADS TO AN INCH.	d = DIAMETER AT ROOT OF THREAD = DIAM. OF HOLE IN NUT.	f = WIDTH OF FLAT AT POINT AND ROOT OF THREAD.	W = WIDTH OF NUT.	T = THICKNESS OF NUT.	w = WIDTH OF HEAD.	t = THICKNESS OF HEAD.
Inches.	Number.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
¼	20	.185 3/16 scant	.0062	½	¼	7/16	3/16
5/16	18	.240 ¼ scant	.0074	19/32	5/16	17/32	¼
⅜	16	.294 19/64 scant	.0078	11/16	⅜	⅝	5/16
7/16	14	.344 11/32	.0089	25/32	7/16	23/32	⅜
½	13	.400 13/32 scant	.0096	⅞	½	13/16	7/16
9/16	12	.454 29/64	.0104	31/32	9/16	29/32	½
⅝	11	.507 ½ full	.0113	1 1/16	⅝	1	9/16
¾	10	.620 ⅝ scant	.0125	1¼	¾	1 3/16	11/16
⅞	9	.731 47/64 scant	.0138	1 7/16	⅞	1⅜	13/16
1	8	.837 27/32 scant	.0156	1⅝	1	1 9/16	15/16
1⅛	7	.940 15/16 full	.0178	1 13/16	1⅛	1¾	1 1/16
1¼	7	1.065 1 1/16 full	.0178	2	1¼	1 15/16	1 3/16
1⅜	6	1.160 1 5/32 full	.0208	2 3/16	1⅜	2⅛	1 5/16
1½	6	1.284 1 9/32 full	.0208	2⅜	1½	2 5/16	1 7/16
1⅝	5½	1.389 1 25/64 scant	.0227	2 9/16	1⅝	2½	1 9/16
1¾	5	1.491 1½ scant	.0250	2¾	1¾	2 11/16	1 11/16
1⅞	5	1.616 1⅝ scant	.0250	2 15/16	1⅞	2⅞	1 13/16
2	4½	1.712 1 23/32 scant	.0277	3⅛	2	3 1/16	1 15/16
2⅛	4½	1.837 1 27/32 scant	.0277	3 5/16	2⅛	3¼	2 1/16
2¼	4½	1.962 1 31/32 scant	.0277	3½	2¼	3 7/16	2 3/16

Then the diameter of the screw at the root of the thread is taken from the table and laid off from the center line of the bolt and pencil lines *a b* and *c d*, defining that diameter, are drawn. The threads are then stepped off and diagonal lines are drawn to represent the points and roots of the thread, without drawing its outlines at all, as shown in the figure. Usually light lines are drawn to represent the point, and heavier ones to show the root of the thread. This method saves much time, and generally serves its purpose quite as well as the other more laborious way of representing screws.

In drawing a screw and nut, the outside of the screw is usually shown, and, as in figs. 162 and 165, the nut is shown in section.

Fig. 163 represents a section of a nut without the screw. The only peculiarity about it is the inclination of the lines which represent the threads. These, it will be seen, are inclined in the reverse direction to those in fig. 162. The reason for this will be apparent if we follow the thread in fig. 162 from 1 to 1′, and then notice that the dotted lines, which represent the thread on the opposite side of the screw, are inclined the reverse way to the full lines 1 1′. The dotted lines in fig. 162 are shown by full lines in fig. 163.

Fig. 169.



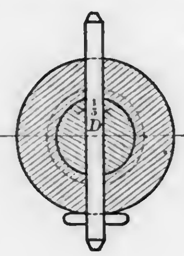
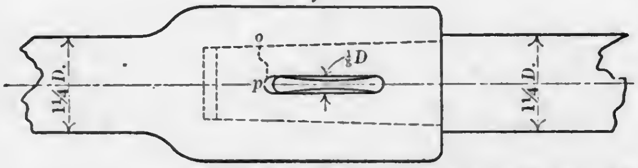


Fig. 170.

Fig. 171.



COTTER JOINT: SCALE, 3 IN. = 1 FT.

TURNBUCKLE AND SWIVEL.

Figs. 166 and 167 are two views of an ordinary turnbuckle, and show the use of right and left-hand thread screws. As shown by the way the threads are drawn, the screw on the rod *A* is right-handed, and that on *B* is left-handed. It is obvious that by turning the turnbuckle in one direction that the rods will be drawn toward each other, and if turned in the reverse direction they will separate. The student should draw these and fig. 168 full size. The method of doing this will be evident from the engraving without other explanation.

Fig. 168 represents a section, what is called a *swivel*, which is used for the same purpose as a turnbuckle. Instead of being

TURNBUCKLE· SCALE, ⅜ IN. = 1 IN.

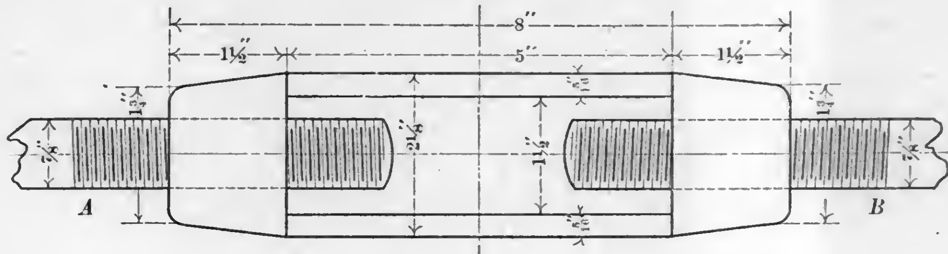


Fig. 166.

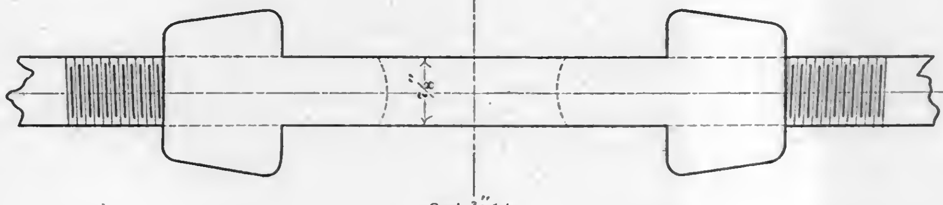


Fig. 167.

Scale ⅜″=1 In.

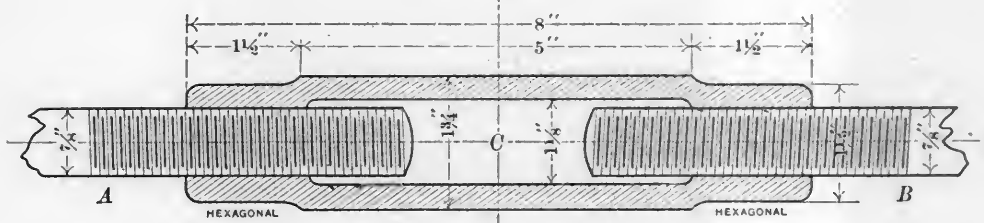


Fig. 168.

SWIVEL

SWIVEL: SCALE, ⅜ IN. = 1 IN.

Fig. 172.

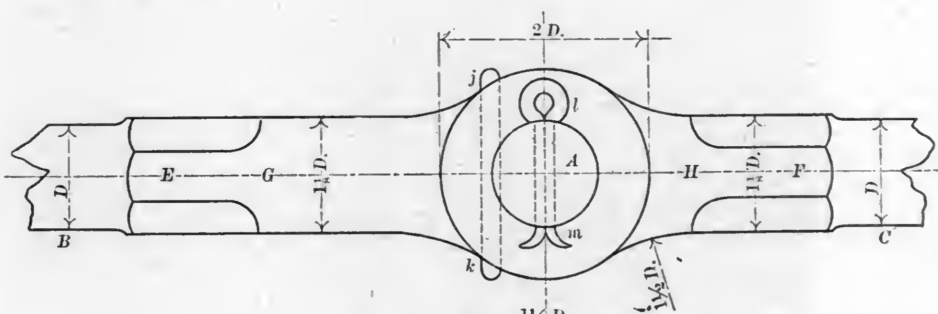
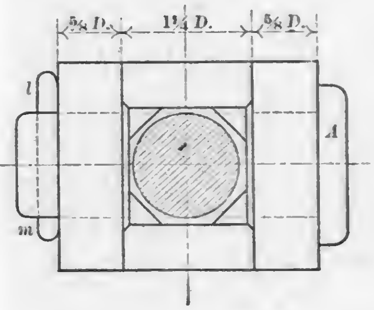


Fig. 174.



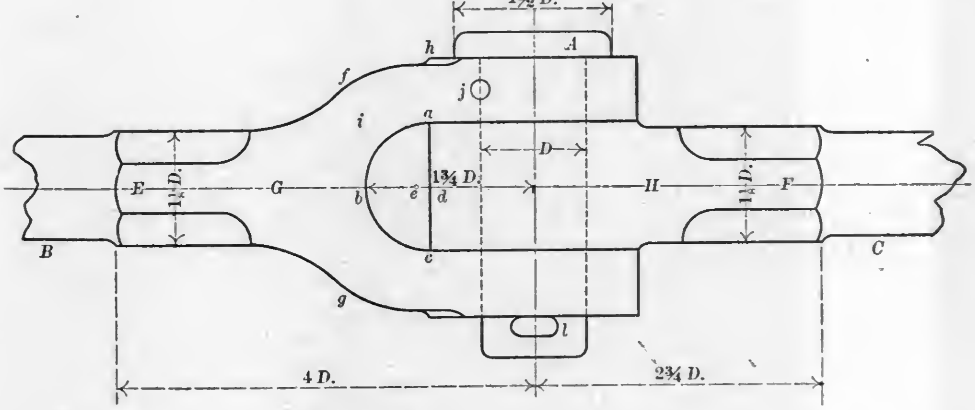


Fig. 173.

KNUCKLE JOINT: SCALE, ¼ IN. = 1 IN.

made open like the turnbuckle, the part *C*, which forms the nuts of the swivel, and which is shown in section in the engraving, is tubular. The ends are made hexagonal, so that it can be held with a wrench to turn it. The rod *A* has a right-hand, and *B* a left-hand thread, the same as the turnbuckle.

COTTER OR KEYED JOINT.

Figs. 169 is a longitudinal, and fig. 170 a transverse, section on the line *e f*, and fig. 171 a plan of a cotter joint, which is used for connecting two parts of a rod, as a valve-stem, pump-

rod, etc. In making such joints they are sometimes made tapered or conical in the socket *a b c d*, as shown in the engraving, and sometimes they are made cylindrical.

The figures and letters on the engraving show how to proportion such a joint of any dimensions. Thus the diameter D on the line *e f* is taken as the unit or standard from which the other parts are proportioned. In the engravings $D=1\frac{1}{2}$ in. The distance *g h* should then be three-fourths of D, or $1\frac{1}{8}$ in. The width of the key or cotter K at *h i* should be $1\frac{1}{3}\,D=2$ in. The outside diameter *k l* of the socket is equal to $2\,D=3$ in., and that of the two rods at *m* and *n* $1\frac{1}{4}\,D=1\frac{7}{8}$ in. The thickness of the key, shown in figs. 170 and 171, is $\frac{1}{8}\,D=\frac{3}{16}$ in. or $\frac{5}{16}$ in. nearly. The point at which such a joint usually breaks is at the place indicated by the dotted line *o p*, fig. 171. This, it is supposed, is liable to occur if the cotter K does not fit its seat perfectly, and bears unequally at the upper or lower edges *q* or *v*, so as to concentrate the strain on the rod at one of those points, and thus start a crack or fracture. To avoid this, it is recommended that the edges of the keyhole be slightly rounded at its upper and lower edges *q* and *v*, so that the bearing will always be some distance from the edge of the hole. The student should design such a joint with a diameter of say $1\frac{3}{4}$ in. at D and draw it full size.

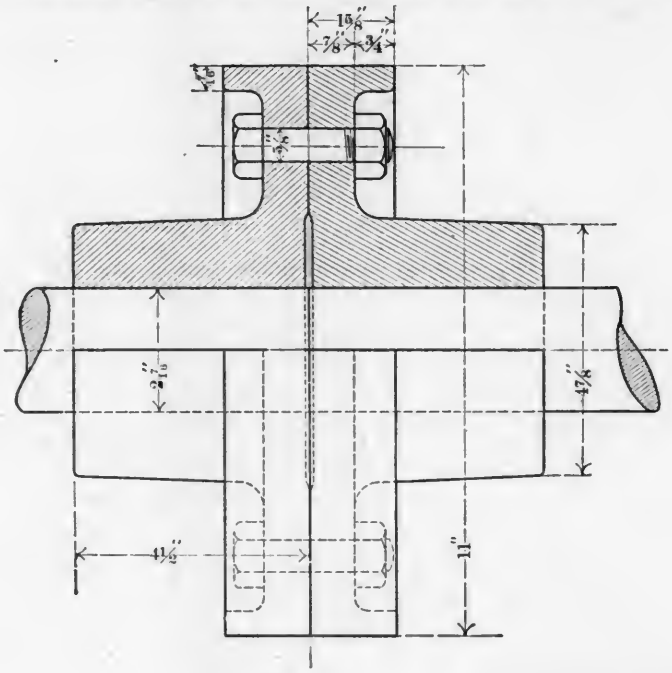


Fig. 175.

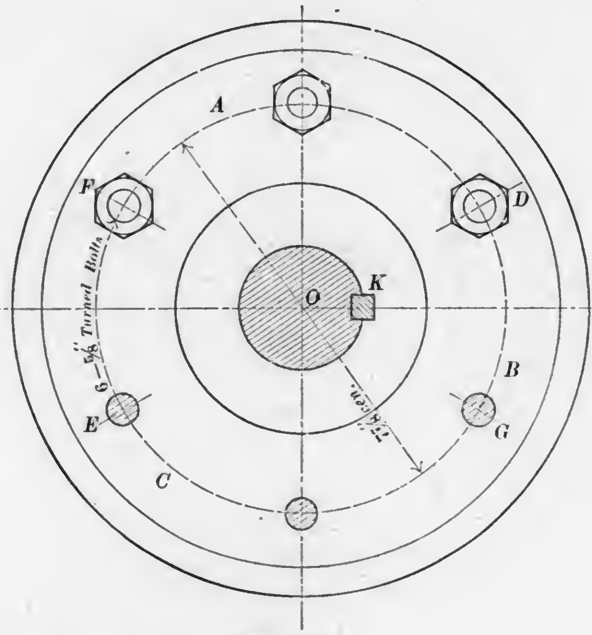


Fig. 176.

PLATE COUPLING: SCALE, 3 IN. = 1 FOOT.

KNUCKLE JOINT.

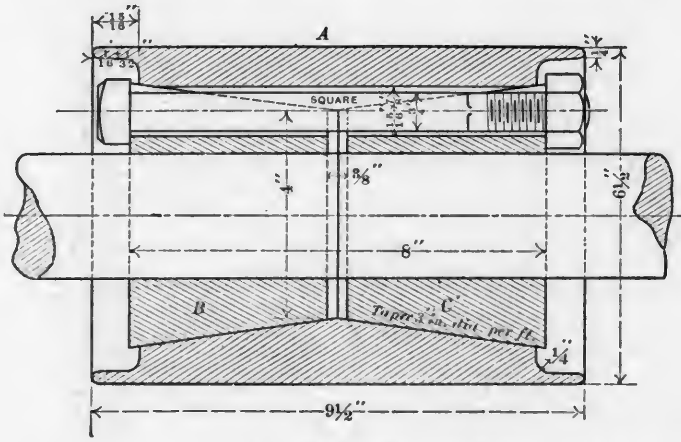
Figs. 172, 173 and 174* represent three views of a flexible joint. The figures and letters on these are also intended as a guide in proportioning joints of this kind, the diameter D of the rods B and C being taken as the unit or standard. The pin A should be the same diameter as the rods. The other proportions are shown by the figures and letters.

When a round rod, as B and C, joins another part which is square or rectangular, as G or H, the transition of form from one to the other is apt to appear awkward. For this reason it is customary to make a portion, as E and F, between the round and rectangular parts octagonal. Such a "*finish*," as it is called, is shown in the engravings, the drawing of which presents no special difficulty. In drawing the curve *a b c* the center should be taken at *d*. In drawing the curves *f* and *g* the center should be moved to the left a short distance, so as to give more strength at *i*, where the forked end of the rod B is subjected to greater strain than it is at *a h*.

The pin *j k* is intended to prevent the pin A from turning in the forked end. The pin A is held in its place by a split pin, *l m*.

The learner should draw a knuckle joint of this kind, full size, with rods B and C $1\frac{3}{4}$ in. diameter, and proportion the parts as indicated by the engravings.

Fig. 177.



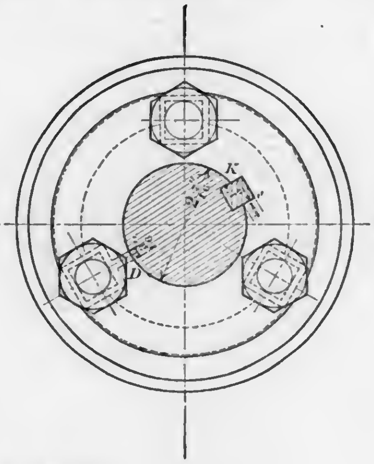


Fig. 178.

DOUBLE-CONE COUPLING: SCALE, 3 IN. = 1 FOOT.

SHAFT COUPLING.*

Figs. 175 and 176 represent what is called a *plate-coupling* for shafting used in transmitting power. In fig. 175 the upper half is shown in section and the lower half is an outside view. The coupling is made in two halves, which are each keyed to the end

* These engravings are taken from Machine Drawing and Design by William Ripper.

* The drawings of this, the double cone coupling and the 30 in. pulley were furnished by the Robert Poole & Son Company, of Baltimore.

of a shaft by keys, one of which is shown at K, and are bolted together with six bolts, as shown. In laying off the bolts, as shown in fig. 176, a circle, $A\ B\ C$, is drawn, and its circumference is subdivided into six parts with its own radius. It may also be conveniently divided by drawing lines $D\ E$ and $F\ G$ through the center O, and intersecting the circumference of the circle. The bolts in the lower half of fig. 176 are represented in section to save time in drawing. The figures should be drawn in full or half size.

Figs. 177 and 178 represent what is called a *double-cone coupling*, also used for uniting parts of a shaft together. In fig. 177 the coupling is shown in section with the shaft inside. The coupling consists of an outer shell, A, made of cast-iron, and two cones, B and C, which are turned to fit into the inside of the shell A, which is bored out to receive them. These cones are cut apart longitudinally or parallel with their axes, as shown at D, fig. 178. Both the cones and the shell have grooves in them to receive square bolts, the forms of both of which are shown in fig. 178. The cones are keyed to the shafts as represented at K, fig. 178. When the cones are inserted inside of the shell, and are drawn together by screwing up the bolts, their conical form and that of the openings in the shell cause them to contract and grasp the shafts tightly, and also to fit the openings in the shell perfectly. If at any time they should get loose, they can easily be made tight by screwing up the nuts on the bolts. Figs. 177 and 178 should be drawn either half or full size.

(TO BE CONTINUED.)

Manufactures.

Marine Engineering.

THE Iowa Iron Works, Dubuque, Ia., have recently completed the steamboat *Herold* for the line between St. Louis and Memphis. She is 245 ft. long, 34 ft. beam, and has a steel hull, with five water-tight compartments. There are two engines, each 19 in. cylinder and 8 ft. stroke, and four double-flue boilers, 4 ft. diameter and 26 ft. long.

THE Continental Iron Works, Brooklyn, N. Y., report a steadily increasing demand for their corrugated boiler flues. A number of orders have recently been received for vessels building on the Lakes, besides others for the seaboard. All the new naval vessels use these corrugated furnaces in their boilers.

AT the yard of Neafie & Levy, in Philadelphia, the new steamer *City of Seattle*, for the Puget Sound & Alaska Steamship Company is nearly completed. She is 260 ft. long, 40 ft. beam, and 17 ft. depth of hold, and of 1,410 tons register. She has accommodations for 250 passengers. The engines are of the compound type, having cylinders 32 and 60 in. in diameter by 36 in. stroke. Steam is supplied by two steel boilers, each 13 ft. in diameter by 14 ft. long, carrying a pressure of 145 lbs. The propeller is 11 ft. in diameter, with a pitch of 18½ ft. On her trial trip she made a speed of 16½ knots an hour.

THE smallest triple-expansion engine built in the United States, according to the *American Shipbuilder*, has just been completed by Riley & Cowley, Brooklyn, N. Y., for the 50-ft. steam launch *Secret*, of Washington. The cylinders are 4 in., 6½ in., and 10 in. in diameter and 8 in. stroke.

Manufacturing Notes.

THE Sterling Emery Wheel Company has decided to move its works from West Sterling, Mass., to Tiffin, O. The change is made on account of the growth of business making an enlargement of the works necessary, and also because of the advantages to be secured by the use of natural gas.

THE business offices of the Dunham Manufacturing Company are now located at 703–7 Phenix Building, Chicago. All correspondence for the Company should be addressed to that office.

THE Bucyrus Steam Shovel & Dredge Company, Bucyrus, O., has its works very busy on orders, and has turned out this year a large number of dredges and steam shovels.

THE Franklin Steam Boiler Works of McNeil & McLachlin (Greenpoint), Brooklyn, N. Y., are constructing a sheet steel water trough for the New York Central & Hudson River Railroad Company. It will be delivered in 60 ft. sections. The total weight is over 75 tons. This concern has an extensive line of work in its shops destined for Detroit, Mich., and Toronto, Can.

Cars.

THE Harrisburg Car Manufacturing Company is building 400 box cars for the Richmond & Danville Railroad.

THE shops of Murray, Dougall & Company, Milton, Pa., are building 100 box cars for the Long Island Railroad.

THE Wells & French Company, in Chicago, is building 750 freight cars for the Illinois Central Railroad.

THE Missouri Car & Foundry Company, in St. Louis, is building 300 box cars for the Louisville, New Orleans & Texas Railroad.

Locomotives.

THE Brooks Locomotive Works, Dunkirk, N. Y., are building six ten-wheel passenger engines for the Atchison, Topeka & Santa Fé Railroad. They have 19 × 26-in. cylinders and 63-in. driving-wheels; the boilers are 60 in. in diameter of barrel.

THE Buffalo, Rochester & Pittsburgh Railroad has ordered six new freight locomotives from the Baldwin Locomotive Works. The Baldwin Works are building 20 ten-wheel freight engines, with 17 × 24-in. cylinders for the Lake Shore & Michigan Southern.

THE shops of H. K. Porter & Company, in Pittsburgh, are building four mine locomotives to go to Mexico.

THE Rogers Locomotive Works, Paterson, N. J., are building three locomotives for the Monterey & Mexican Gulf; four to go to Cuba; two to go to Jamaica; five for the Chesapeake & Ohio, and 22 for the New York Central & Hudson River Railroad. They are also building two snow-plows for the Jull Manufacturing Company.

THE Schenectady Locomotive Works are building five heavy passenger engines for the Cincinnati, Hamilton & Dayton Railroad.

Bridges.

THE Southern Bridge Company, Birmingham, Ala., is building an iron bridge at Clinton.

THE Missouri Valley Bridge & Iron Works are building an iron bridge near Dallas, Tex., over the Trinity River.

THE Pittsburgh Bridge Company is building an iron bridge over Sandy River in Maine, for the Sandy River Railroad.

THE King Iron Bridge & Manufacturing Company, of Cleveland, O., is building an iron bridge at Paris, Tex.

THE Vermont Construction Company, St. Albans, Vt., is building an iron bridge near Montgomery, Ala., over Catoma Creek.

THE Elmira Bridge Company has the contracts for a number of bridges for the Lehigh Valley Railroad System. Among others, those for a new single-track, four-span bridge at Wilkesbarre, Pa., across the Susquehanna River, and a five-span, double-track bridge at Athens, Pa, across the Chemung River. The latter replaces an existing bridge considered too light for the heavy rolling stock. The Schuylkill Viaduct, at Schuylkill Haven, Pa., 1,450 ft. long, has just been opened for trains and the shops are now working on the Westwood Junction Bridge of two spans, one 155 ft. 9 in. and one 132 ft. long. These spans, with a number of large plate girders, keep the shops pretty busy.

THE Chicago, Burlington & Northern Railroad will bridge the Mississippi River at Winona Minn. Mr. George S. Morison is Consulting Engineer. Mr. Morison is also Consulting Engineer on the Mississippi River bridges at Burlington, Ia., to replace the well-known Chicago, Burlington & Quincy crossing, and at Memphis, Tenn., for the Kansas City, Fort Scott & Memphis. The latter, when completed, will be the largest cantilever span in the country, 790 ft. clear.

THE Louisville & Nashville Railroad has let contracts to bridge shops as follows: Edge Moor Bridge Works, 706 tons; Pencoyd Iron Works, 615 tons; Louisville Bridge & Iron

Company, 347 tons; Mount Vernon Bridge Company, 176 tons; Shiffler Bridge Company, 74 tons.

THE erection of the Newark Bridge on the New York extension of the Lehigh Valley is rapidly approaching completion. The bridge is a crossing of the Pennsylvania Railroad tracks and is of two heavy, double-track spans, one 154 ft. and one 168 ft. 9 in. It was built and is being erected by the Edge Moor Bridge Works.

THE Delaware, Lackawanna & Western has let the contract for the Delaware River bridge at Easton, Pa., to the Passaic Rolling Mill Company, of Paterson, N. J. It has five spans of 150 ft. each.

THE New York Central & Hudson River Company has let contracts for 22 highway bridges to the Rochester Bridge & Iron Works. The Elmira and the Hilton Bridge Companies are also doing considerable bridge work for this road.

THE Edge Moor Bridge Works have the contract for a 1,200-ft. viaduct in the city of Richmond, Va.

MR. A. P. BOLLER, Consulting Engineer for the Board of Public Works in New York, has awarded the contract for the One Hundred and Fifty-fifth Street viaduct to the Union Bridge Company. The total weight of the structure is about 4,000 tons. In general it will consist of plate girders resting upon columns. Date for completion is set at June 1, 1892.

THE Michigan Central has let the contracts for several bridges to the Pencoyd Iron Works, of Pencoyd, Pa.

THE Keystone Bridge Company has secured the contract for the Contentnea Creek bridge for the Atlantic Coast Line. It is a through Pratt truss span 112 ft. center to center of end pins.

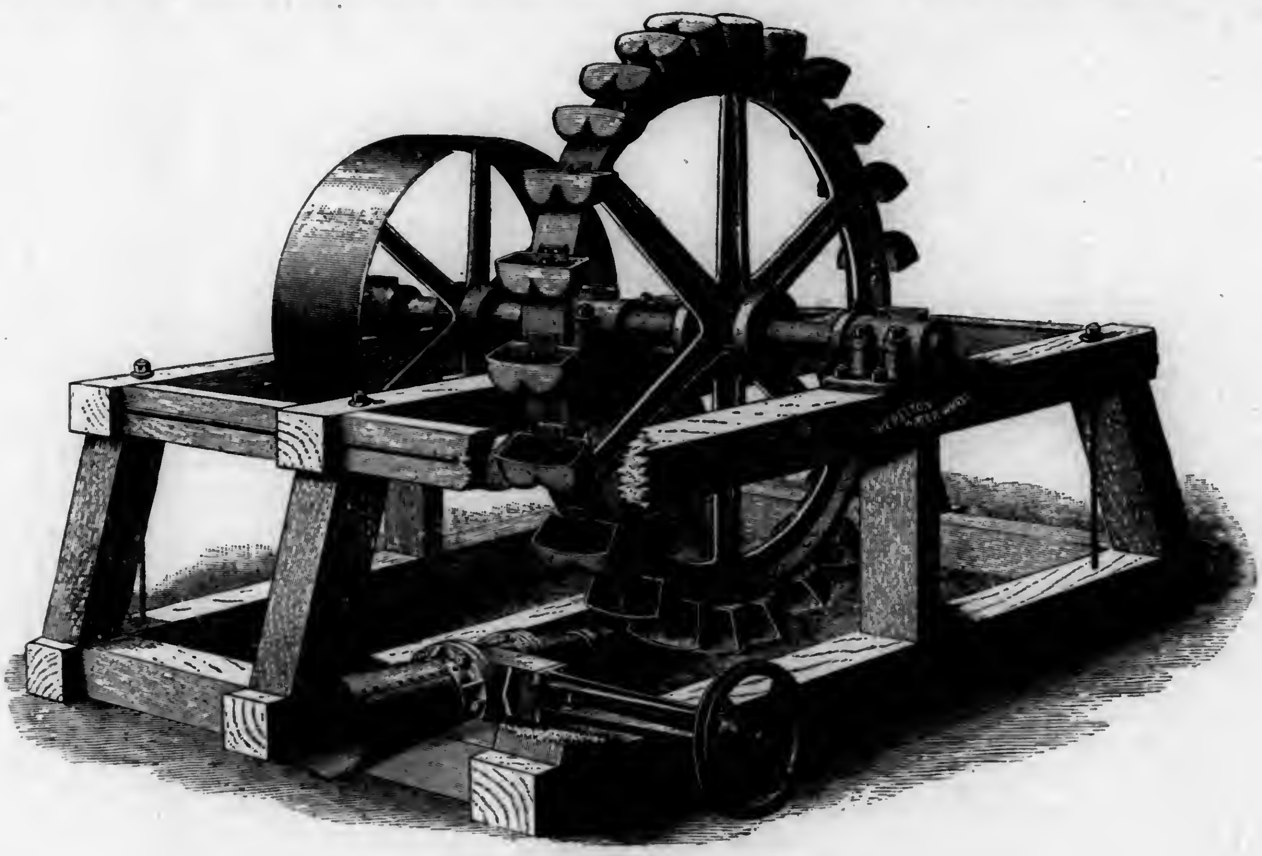
THE contract for a highway bridge across the Mississippi River, between Lyons and Fulton, Ia., has been let to the Chicago Bridge & Iron Company. It consists of five spans, one 200 ft., three 330 ft., and one 360 ft. long and will be practically of steel with cylinder piers of iron. Total weight about 600 tons. Mr. C. F. Loweth, of St. Paul, is the engineer in charge.

THE Pittsburgh, Allegheny & Manchester Traction Company has consolidated its interests with those of the Sixth Street Suspension Bridge Company, and will use the proposed Sixth Street Bridge across the Allegheny River at Pittsburgh, Pa. Plans have been submitted by Gustav Lindenthal and G. W. Ferris, and while both have been recommended by Colonel Flad, it is probable that those of the former will be adopted.

THE new eyebar manufacturing plant and large testing machine of the Phœnix Bridge Company are now in working order, and eyebars for the St. Louis terminal to the Merchants' Bridge are being manufactured with fair success.

THE Delaware & Hudson Canal Company has let the contract for the bridge across the Hudson River and Canal at Fort Edward, N. Y., to the Hilton Bridge Company, of Albany. The bridge comprises nine deck lattice girder spans, as follows: Canal bridge, one span 105 ft., two spans 110 ft. and one span 121 ft. 9 in.; river bridge, four spans 105 ft. 9 in., one shore span 105 ft. 9 in. and one span 108 ft. 7 in. The contract calls for completion November 1, 1899.

The Pelton Water-Wheel.



THE PELTON WATER-WHEEL.

THE Pelton water-wheel, which is coming into extensive use on the Pacific Coast, is a high-pressure wheel, the power of which does not depend so much on its diameter as upon the head and amount of water applied to it. As shown in the engravings, it is very simple in construction, and the only requirement as to size is that the wheel shall be large enough to carry buckets of the proper size to handle the stream applied.

It may be described as a tangential, pressure and reaction wheel. It is simply a wheel of the proper strength, to the rim of which are attached buckets of the form shown, upon which the stream of water is directed by a nozzle placed below. This nozzle may be single and directed as shown in the engraving, or a double nozzle may be used, the latter arrangement being preferred with a low head of water, and also where the quantity of water available is variable.

The advantages claimed for this wheel are chiefly as follows:

1. Its great simplicity and the absence of wearing parts, which make it a very durable wheel. The only repairs needed usually are the renewal of the buckets.

2. The buckets being open, with a free discharge, it can be run with water carrying sediment, and the wheel is never clogged with roots or other foreign substances, or by ice in a cold climate.

3. The power may be varied widely without impairing the efficiency of the wheel. This is accomplished by simply chang-

ing the tip of the nozzle, varying the size of the stream. It can thus be adapted to a water-power where the supply is variable.

4. The simplicity of its mounting, the ease with which connections are made, and the fact that the wheel can be placed at any convenient point to which the water can be conveyed by a pipe. It is also claimed that, while the wheel can be run with a low head of water, it will utilize to the fullest extent a small stream with a considerable head.

It may be mentioned that there are six Pelton wheels now in operation at the Sutro Tunnel level of the Chollar Mine in Nevada, using water under a head of no less than 1,680 ft. These wheels run a Brush electric plant, from which power is furnished to the California Mill, the electricity being transmitted to the surface by steel cables. In this case the wheels used are 40 in. in diameter and are run at 900 revolutions per minute. These wheels are of phosphor-bronze, weighing 220 lbs. each; they are run with nozzles ⅝ in. in diameter, and develop about 125 H.P. each.

At Aspen, Col., there is an electric light and power plant which is run by eight 24-in. Pelton wheels; they run at 1,000 revolutions per minute under a head of 820 ft., and develop about 175 H.P. each. Reducing tips are used to the nozzles here, so that the power can be varied as needed. Water is carried to the power station by a single line of pipe, consisting of 500 ft. of 16-in. and 3,500 ft. of 14-in. pipe, discharging into a receiver, from which separate connections are made to each wheel.

The Pelton wheel seems especially adapted to the running of an electric station, as it can be run up to a high speed, and so can be connected directly to a dynamo, without using intermediate gearing or belting to increase the speed.

It also seems to be well adapted to small powers, and where it is possible or necessary to increase the power, the addition of more wheels is easily made.

In some cases a hydraulic governor is used, with a deflecting nozzle, and this arrangement has been found to work very well.

In the accompanying cuts fig. 1 is a perspective view of a wheel and framing; fig. 2 is an elevation, and fig. 3 a plan of a 6-ft. wheel of standard pattern. This is a large size, but shows very well the design and construction, which is substantially the same in all. The arrangement of the nozzle is, of course, varied where two or more are used.

This wheel is manufactured by the Pelton Water Wheel Company of San Francisco, Cal., who will furnish all necessary information.

The Blaine Vitrified Clay Tie.

In relation to the description of this tie, published in the August number of the Journal, page 377, a valued subscriber and correspondent, Mr. Edward Hill, of Indianapolis, furnishes the following interesting particulars:

"The most important element in the tie is the vitrified clay base, which stands 10 in. high. The diameter on top is 10 in.; the bottom is oval in shape, the major and minor axes of the ellipse being 15 in. and 22 in. respectively.

"The first lot made were put under a freight track in the yard in Dayton, O. All the freight trains going east and west through the yard pass over this track, and the ties are to-day in as perfect condition as when put in three years ago.

"The clay blocks were tested for crushing in a wheel press, and withstood a strain of 55 tons before cracking, which took place longitudinally with the blocks. In laying they are spaced 16 in. center to center, which gives the track about the same bearing surface as with ordinary cross-ties. Every other set of blocks is connected together by the cross-bar. The cost of manufacture of these ties is about 70 cents.

"There is a wooden block on top of the clay base, which gives a surface similar to a wooden tie. Fire-clay vitrified and burned hard has about the same crushing strength of sandstone, and the philosophy of the clay tie bases is that they will not rot and are impervious to water, while the wooden block acts as a cushion to give some elasticity, similar to the surface of an ordinary wooden tie.

"The clay blocks are admirably adapted for street railroads in large cities, where good asphalt or other pavements are necessary; being of a permanent nature, they will not decay under the surface like timber."

OBITUARY.

George W. Tilton died in Chicago, August 17, aged 60 years. He was born near Manchester, N. H., and for several years was employed in the Manchester Machine Works. About 1858 he went to the Chicago, Burlington & Quincy shops at Aurora, Ill., as Foreman, and in 1860 was appointed Foreman of the Chicago & Northwestern shops at Fulton, Ill. In 1870 he was made Master Mechanic, and in 1875 was appointed Superintendent of Motive Power and Machinery for all the Chicago & Northwestern lines; in 1881 the Car Department was also placed under his charge. Mr. Tilton's death was the result of a slight accident on the road, a collision, which did not damage the car, throwing him forward and fracturing his skull, which struck the corner of a trunk. He was highly esteemed by the officers of the road and by all his associates.

PERSONALS.

Emil Kuichling has been appointed Chief Engineer of the water-works at Rochester, N. Y.

A. H. Watts has been appointed Superintendent of Motive Power of the Cincinnati, Jackson & Mackinaw Railroad.

Major George W. McNulty is Engineer of Construction of the new cable road and plant of the Broadway Railroad in New York.

W. H. V. Rosing has been appointed Division Master Mechanic on the Illinois Central Railroad. He has been Chief Draftsman of the road for several years.

Robert Miller has been appointed General Superintendent of the Michigan Central Railroad. He has been on the road since 1876, at first as Master Car-Builder and later as Assistant General Superintendent.

A. W. Gibbs has been appointed Superintendent of Motive Power of the Central Railroad of Georgia, succeeding T. L. Chapman, who has resigned. Mr. Gibbs was recently on the Richmond & Danville Railroad.

H. S. Jacoby has been chosen Assistant Professor in the College of Civil Engineering in Cornell University, Ithaca, N. Y., and will have charge of the department of Graphics and Bridge Engineering. Professor Jacoby has been for some time Assistant to Professor Merriman in Lehigh University.

T. A. Fraser has resigned his position as Master Mechanic of the Minneapolis, St. Paul & Sault. Ste. Marie Railroad, to take charge of the car shops of the Wells & French Company, in Chicago. J. P. Holland and F. A. Haines accompany him there as Foremen. Their successors are Edward A. Williams as Master Mechanic, E. S. Barrett as Foreman of Car Shops and L. C. Hitchcock as General Foreman of the Machine Shop.

PROCEEDINGS OF SOCIETIES.

American Association for the Advancement of Science.—The annual meeting of this Association began in Indianapolis, August 20. A general meeting was held on the first day, at which addresses of welcome were made, the reports of the General Secretary and of the Council read, and other routine business transacted. As usual, the Association then separated into sections for the reading of papers and discussions, the sections being as follows: A, Mathematics and Astronomy; B, Physics; C, Chemistry; D, Mechanical Science and Engineering; E, Geology and Geography; F, Biology; H, Anthropology; I, Economical Science and Statistics.

The section on Physics was presided over by Professor Cleveland Abbe, and that of Engineering by Professor Denton, of the Stevens Institute. His opening address was on the History of Attempts to Determine the Relative Value of Lubricants by Mechanical Tests.

The meeting continued for a week, a large number of papers being read in the various sections. It was diversified by excursions to Terre Haute, where the members visited the Rose Polytechnic Institute, and a number of manufacturing establishments, and by a trip through the Natural Gas Belt of Indiana, including the towns of Kokomo, Marion, Muncie, and Anderson.

Among the papers of interest read in the mechanical section were several by Professor Thomas Gray on Testing Materials; by Professor W. A. Rogers on the Dividing Gauges; and by Mr. William Kent on the Standard Efficiency for Steam Engines.

At the meetings of the Council the usual action was taken on committee reports, and the memorials were adopted to Congress on the advisability of making the metric system a standard in

all government transactions, and on the adoption of measures for the protection of forest lands.

At the concluding general business session a number of new members and fellows were elected. It was decided to hold the next meeting in Washington, in August, 1891. The following officers were elected for the ensuing year:

President, Albert B. Prescott, Ann Arbor, Mich.

Vice-Presidents: A, Mathematics and Astronomy, E. W. Hyde, Cincinnati, O.; B, Physics, F. E. Nipher, St. Louis; C, Chemistry, R. C. Kedzie, Agricultural College, Michigan; D, Mechanical Science and Engineering, Thomas Grey, Terre Haute; E, Geology and Geography, J. J. Stevenson, New York; F, Biology, J. M. Coulter, Crawfordsville, Ind.; H, Anthropology, Joseph Jastrow, Madison, Wis.; I, Economic Science and Statistics, S. Dana Horton, Pomeroy, O.

Permanent Secretary, F. W. Putnam, Cambridge, Mass.

General Secretary, Harvey W. Wiley, Washington, D. C.

Secretary of the Council, A. W. Butler, Brookville, Ind.

Auditors, Henry Wheatland, Salem, Mass., Thomas Meehan, Germantown, Pa.

Secretaries of Sections: A, Mathematics and Astronomy, E. D. Preston, Washington, D. C.; B, Physics, A. N. Macfarlane, Austin, Tex.; C. Chemistry, F. H. Norton, Cincinnati, O.; D, Mechanical Science and Engineering, William Kent, New York; E, Geology and Geography, W. J. McGee, Washington, D. C.; F, Biology, A. J. Cook, Agricultural College, Michigan; H, Anthropology, W. H. Holmes, Washington, D. C.; I, Economic Science and Statistics, B. E. Fernow, Washington, D. C.

Treasurer, William Lilly, Mauch Chunk, Pa.

The attendance at this meeting was large and the meeting was considered generally a very successful one.

American Institute of Mining Engineers.—As heretofore announced, the fall meeting was held in New York, September 29 and 30, but this meeting was to be chiefly preparatory to the joint meeting with the Iron and Steel Institute of Great Britain, the American meeting of that body beginning October 1.

Iron and Steel Institute.—The programme for the American meeting of this body is announced as follows: The first meeting to be held in New York on the morning of October 1; in the afternoon the members, with those of the Institute of Mining Engineers, proceed on an excursion up the Hudson River. On October 2 the unveiling of the Holley memorial in Washington Square takes place, and an address is delivered in Chickering Hall by Mr. James Dredge.

After the various excursions the programme announced is as follows: On October 4 the members will proceed by special train to Philadelphia remaining there until October 7, when they will proceed to Lebanon and Harrisburg, and on the following day to Johnstown and Altoona, arriving at Pittsburgh in the evening. At Pittsburgh an international meeting will be held, at which a number of papers will be read. A list of these papers and also of those to be read at the New York meeting has already been published.

The general excursion will proceed from Pittsburgh to Chicago, and at the close of the visit to Chicago will divide into two parties, going respectively North and South. The Northern excursion will visit Menominee, Gogebic, and Marquette iron ranges and the Lake Superior copper district, returning to New York *via* the Sault Ste. Marie Canal, the Sudbury (Canada) nickel and copper mines, and Niagara; while the Southern excursion will go from Chicago to Birmingham, Shelby, and Anniston, Ala., returning to New York *via* Chattanooga, Tenn., Middlesborough, Ky., Roanoke, Cripple Creek iron mines, Pocahontas coal mines, Luray, Va., and Washington. Both excursions will reach New York about October 28.

American Society of Civil Engineers.—The first meeting of the session was held in New York, September 3, when the usual routine business was transacted and notes on a mountain slide by William J. Curtis were read, the paper being afterward discussed by members present.

Engineers' Club of Cincinnati.—At the July meeting a committee of two was appointed to investigate the question whether the Club should become a member of the Association of engineering societies.

The following question was presented and received considerable discussion, which was taken part in by Messrs. Nicholson, Whinery, Ruggles, and Schenk: "In a City of 300,000 inhabitants what is the smallest quantity of water per capita per day necessary for the necessities and comforts of its citizens, provided there is neither waste nor unnecessary use of the water?"

Mr. Ruggles read a very interesting historical sketch of the Ohio & Mississippi Railway which embraced a valuable collection of information concerning one of the earliest railways of the country.

Dr. P. H. Dudley, of New York, who was present—having recently returned from an inspection trip with his dynagraph car over the roads of the Queen & Crescent System—entertained the meeting with a description of his apparatus and exhibited some diagrams of the work performed by it.

At the August meeting the committee appointed at the previous meeting presented a partial report.

The question presented for discussion was: "What would be the effect in the case of a Howe truss bridge that had given indications of failing generally, of putting in a support of piles or similar temporary bents midway of the span? What would be the effect if it were a combination bridge or Warren girder?" was discussed by Messrs. Merrill, Stuart, and Nicholson.

Papers on the following subjects were read:

1. Cement Tests, by Philip J. Schopp.
2. Some ideas about River Engineering, by Oswald Dietz.

The latter comprised a suggestion for the establishment of a school for experimental hydraulic engineering.

The first paper, while in itself giving only the results of some experiments on cements, especially on some that had become set by becoming submerged, opened up the always interesting subject of cement and its use, which was discussed quite generally.

New England Roadmasters' Association.—The Eighth Annual Convention was held in Boston, August 20. The following officers were elected for the ensuing year: President, W. E. Clark, Vermont Valley; Vice-President, F. C. Clarke, Housatonic; Secretary and Treasurer, G. S. R. French, Boston & Maine; Chaplain, E. W. Horner, Central Vermont; Executive Committee, C. B. Lentell, F. D. Holbrook, E. W. Horner, and A. C. Stickney.

The first report presented was on Track Repairs in the Winter and Spring Months, and suggested that the use of proper material for road-beds was the best means of preventing injury from frosts, and that six miles of single track, or four miles of double track were the best lengths for sections.

The Committee on Inspection of Road-bed presented a report recommending frequent inspections, and also approving of the system of premiums to section masters. In the discussion of these interesting questions some of the methods of inspection adopted on the Boston & Albany and other roads were given.

On the second day the Committee on Frogs and Switches presented a report which was very fully discussed, members giving their opinions and experience. A great difference of opinion as to the relative merits of the rigid frog and the spring-rail frog was developed, with the balance somewhat in favor of the spring-rail frog. The general opinion was that the greatest cause of wear to frogs and switches was the use of poor and defective wheels.

Reports were also presented on improvements in nut-locks rail saws, tie-plates and other devices.

It was voted to hold the next meeting in Boston on the third Wednesday in August, in 1891. The meeting concluded by a trip to North Adams and through the Hoosac Tunnel, over the Fitchburg Railroad.

Master Mechanics' Association.—Secretary Angus Sinclair has issued a circular giving the Committees for conducting the business for the current year as follows:

1. Exhaust Pipes, Nozzles and Steam Passages. Investigate best form and size in proportion to cylinders: C. F. Thomas, A. W. Gibbs, L. C. Noble, F. C. Smith, John Y. Smith.
2. Testing Laboratories, Chemical and Mechanical: George Gibbs, Phillip Wallis, G. W. West, L. S. Randolph, D. L. Barnes.
3. Advantages and Disadvantages of Placing the Fire-box above the Frames: Fred B. Griffiths, James Macbeth, W. A. Foster, A. G. Leonard, Louis F. Lyne.
4. Relative Value of Steel and Iron Axles: John Mackenzie, J. S. Graham, John S. Cook, W. B. Wall, Thomas Shaw.
5. Purification or Softening of Feed Water: W. T. Small, Harvey Middleton, A. W. Quackenbush, J. B. Barnes, John W. Hill.
6. The Present Status of the Car Coupler Question. Investigate whether this Association can indorse the action of the Master Car-Builders' Association from a mechanical standpoint

in recommending the Vertical Plane Type as a standard: John Hickey, G. W. Rhodes, Sanford Keeler, R. H. Blackall, M. N. Forney.

7. Examination of Locomotive Engineers and Firemen. On their duties relating to the use of fuel, care of the locomotive, and ability to deal with disorder or disability of machinery; to what extent practised, and best plan for conducting the examination: W. H. Thomas, John Player, F. D. Casanave, J. W. Luttrell, L. R. Pomeroy.

8. Operating Locomotives with Different Crews. Investigate the comparative advantages of operating locomotives with different crews on the "first in and first out" plan, and that of confining men to certain engines, the latter not running a greater number of miles than can be rendered by their regular crews; discuss any improvement in the method of running engines: Ross Kells, W. W. Reynolds, W. F. Turrell, C. G. Turner, John A. Hill.

9. Locomotive for Heavy Passenger and Fast Freight Train Service. Investigate the types best suited for this service and the relative economy and safety of eight-wheel, ten-wheel, and mogul locomotives for the service in question: Pulaski Leeds, James Meehan, E. M. Roberts, C. E. Smart, W. A. Smith.

10. Electrical Appliances for Railroad Use. Report on the progress of electricity in motive power, car lighting, signaling, welding, and kindred uses: T. W. Gentry, G. B. Hazelhurst, Albert Griggs, John Ortton, F. W. Dean.

11. Standards of the Association: William Swanston, William Garstang, C. H. Cory, J. S. McCrum, Thomas Shaw.

Disposal of Boston Fund: J. N. Lauder, J. N. Barr, Angus Sinclair.

To Confer with Committee of Master Car-Builders' Association on Bringing Conventions Closer Together: O. Stewart, Charles Graham, David Clark, G. W. Stevens, John Mackenzie.

On Subjects for Investigation and Discussion: William H. Lewis, John Wilson, Peter H. Peck.

Executive Committee and Trustees of Boston Fund and Printing Fund: John Mackenzie, John Hickey, William Garstang, O. Stewart, Angus Sinclair.

Custodian of Boston Fund: J. H. Setchel.

Roadmasters' Association of America.—The Eighth Annual Convention began in Detroit, Mich., September 9, with a large attendance. A number of new members were admitted. The morning session was occupied by the usual routine proceedings.

The Committee on Nut-Locks, Track-Bolts and Spikes presented a report recommending for general use an elastic steel nut-lock washer. For track-bolts $\frac{3}{4}$-in. bolts were recommended for rails under 60 lbs.; $\frac{7}{8}$-in. for rails from 60 to 80 lbs., and 1-in. for rails weighing more than 80 lbs.; hexagonal nuts to be used, with standard threads. Steel spikes were recommended: the best size for general use being $\frac{9}{16}$-in. square and $5\frac{1}{2}$ in. long. On rail-joints the Committee recommended five joints as worthy of trial by the Association: The Weber joint; the Long truss joint; McConway & Torley's reinforcement for angle bars; the improved Fisher joint, and the Cloud joint. These include a supported joint; a suspended joint, and a means of reinforcing existing joints. This report was received and the Executive Committee was instructed to conduct tests of the joints named and to report at the next Convention.

The Committee on Best Method of Instructing Section Laborers presented a report recommending a system of instruction for young laborers and the appointment of assistant foremen on probation. This called out considerable discussion and the report was referred back for further consideration.

At the second day's session the Committee on Interlocking Switches and Signals submitted a report including drawings and descriptions of the Saxby & Farmer machine; the Union Switch & Signal Company's electro-pneumatic apparatus, and the Johnson Signal Company's machines. On this report there was a brief discussion.

Mr. J. W. Craig read a paper comparing the mileage and statistics of railroads in different countries.

The Committee on Best Method for Preserving Cross-Ties presented a carefully prepared report on the different processes for preserving wood, including the creosote, the chloride of zinc, the sulphate of copper, and other processes, with statements of the methods adopted and the expense involved. The discussion of this report was postponed until the next Convention.

The following officers were elected for the ensuing year: President, John Doyle, Detroit, Lansing & Northern; First Vice-President, W. H. Stearns, Chicago & Northwestern; Second Vice-President, James Sloan, Chicago & Eastern Illinois; Secretary and Treasurer, J. P. Ramsay, Cincinnati, Hamilton & Dayton.

It was decided to hold the next Convention at Minneapolis.

South & Southwestern Railroad Club.—This new Club has been organized and will hold its meetings in St. Louis. The first meeting after organziation was to be held on September 25, when a constitution and by-laws were to be submitted.

The officers are: President, E. S. Marshall; Vice-Presidents, William Garstang, J. J. Casey; Secretary, W. H. Marshall.

Western Railroad Club.—The first meeting of the season was held in Chicago, September 16. A Committee report on two unfinished subjects: Relative Cost of Maintaining Rigid Center and Swing Beam Trucks of Freight Cars and Comparative Flange Wear of Wheels, was presented and discussed.

Northwestern Railroad Club.—The first meeting of the season was held in St. Paul, Minn., September 6. The subject for discussion was Fire-Box and Boiler Construction, on which a paper was read by William McIntosh, recommending the use of steel and referring to the Wootten and Belpaire fire-boxes. This paper was discussed by members present.

NOTES AND NEWS.

Ship Canal to Berlin.—One of the results of the great interest now felt in waterways in Germany is a project for a ship canal to connect Berlin with the sea, an outline of which is published in the *Deutsche Bauzeitung*. This project is favored by the generally level nature of the country and the supply of water furnished by the numerous rivers.

Four lines are indicated, any one of which is practicable. The first starts from Hamburg and runs on the south side of the

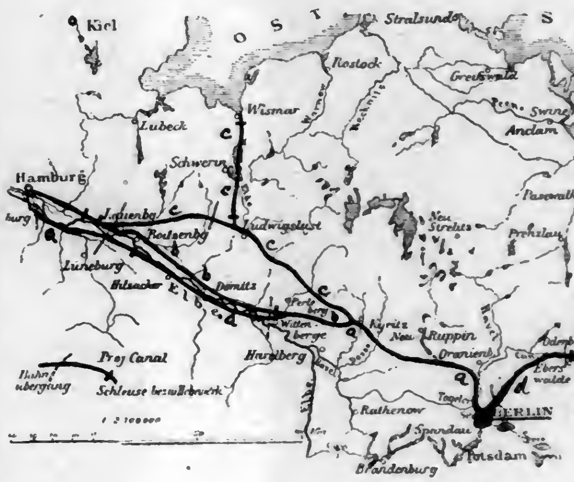


Fig. 1.

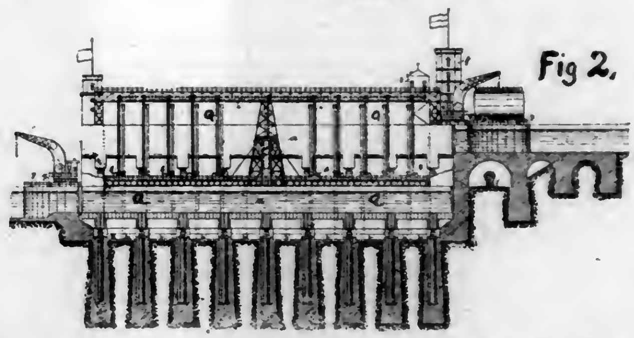


Fig 2.

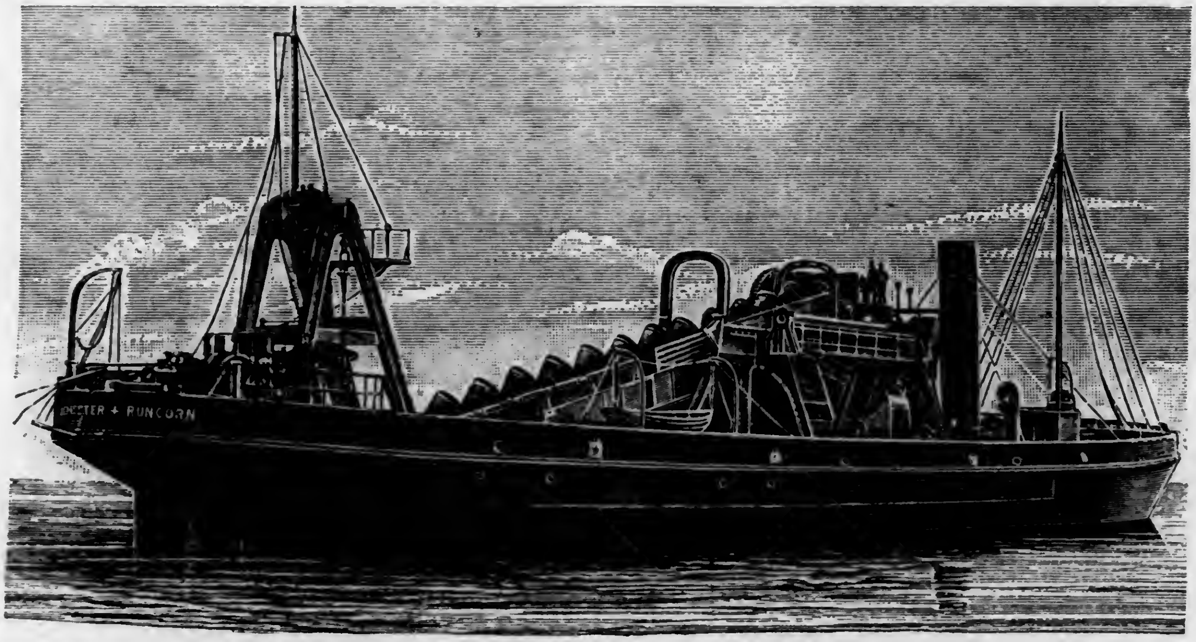
Elbe to Wittenberg, thence eastward to the Havel and south along that stream to Berlin. The second follows the north side of the Elbe to Wittenberg, where it joins the first line. The third leaves the second at Lauenberg, about 14 miles from Hamburg, runs east to Ludwigslust and thence southeast to the first line at Kyritz. The length of these lines is from 160 to 170 miles. The third line has a branch to Wismar on the Baltic Sea. The fourth line is entirely distinct, running from Berlin northeast to the Oder River and then following that river to Stettin; it is about 85 miles long.

The projected lines are shown by the heavy black lines on the accompanying sketch map, fig. 1, the first line being marked

a a a; the second *b b b*; the third *c c c*, and the fourth *d d d*. But few locks would be required; their position is shown in fig. 1 by the black cross lines on the canal.

It is proposed to use the hydraulic lift lock, which has been successfully employed in France and England, by which a greater lift can be secured with a smaller waste of water. A section of one of these locks is shown in fig. 2. The lock or water-box *a a* is raised and lowered by hydraulic lifts set below it, the pumps being placed in the building at the head of the lock. The dimensions proposed are 312 ft. long, 41 ft. wide and 21.3 ft. deep, which would permit the passage of vessels of large size.

A New Hopper Dredge Boat.—The accompanying illustration shows the steam dredge *Manchester*, recently built by the firm of William Simonds & Company in Renfrew, Scotland, for the Manchester Ship Canal. It is a single ladder, stern-well, hopper dredger, built of steel, and having some interesting details of construction, in which it differs from other dredge-boats previously built. The first point of difference is the division of the stern for the projection of the bucket ladder, other dredges having this division at the bow. The advantage of the new arrangement is that the vessel presents a solid and not a divided bow, and is better able to withstand rough weather. The boat is fitted with two lines of steel shafting carried fore and aft, and has four steel propellers, two at the bow and two at the stern, thus obviating all necessity for turning. There are three rudders, one at the bow and two at the stern all controlled from the dredge by steam steering gear.



The boat is 190 ft. long; 39 ft. beam, and 16 ft. 6 in. molded depth. The draft is 14 ft. loaded and 10 ft. light. It is propelled by two triple-expansion condensing engines, capable of propelling the vessel when loaded at the rate of nine knots per hour, and so arranged that either engine will drive the dredging machinery when disconnected from the propeller. The cylinders are 15½ in., 25 in. and 41 in. in diameter and 27 in. stroke. Steam is furnished from two steel tubular boilers, built to carry a working pressure of 150 lbs.

The hoppers are placed amidships and have a capacity for 850 tons of dredging, while the dredger will work to a depth of 35 ft. below water level when the bucket ladder is at an angle of 45°. The vessel is designed to deal with hard clay, mud, soft sandstone and similar material. The buckets consist of a set of steel backs with links so designed that they can be fitted with removable interchangeable steel bodies and lips. In this way the large bodies can be removed from the chain without breaking its continuity; when hard material is to be dealt with a set of special steel bodies of less capacity can be fitted on, every third back being armed with a set of ripping claws or picks for disintegrating the material. A friction connection is fitted between the engines and the top tumbler for the purpose of taking the strains arising from sudden shocks to the machinery when working in hard ground. At a trial near Greenock this dredge loaded clay at the rate of 1,000 tons per hour.

The Largest Reservoir.—The *Indian Engineer* says that, omitting lakes, which are in many cases natural reservoirs, the largest reservoir or artificial lake in the world is the great tank of Dhebar, 20 miles southeast of Udaipur, Rajputana, which covers an area of 21 square miles. The masonry dam is 1,000 ft. long by 95 ft. high; 50 ft. wide at the base and 15 at the top. In Southern India also, there are some immense reservoirs. That of Cumbum, is formed by damming the Gundlakamana River by a dam 57 ft. high, thrown between two hills. This reservoir has an area of 15 square miles. The Sulekere Reservoir in Mysore is a very little smaller, and, next to Cumbum, is the finest in Southern India.

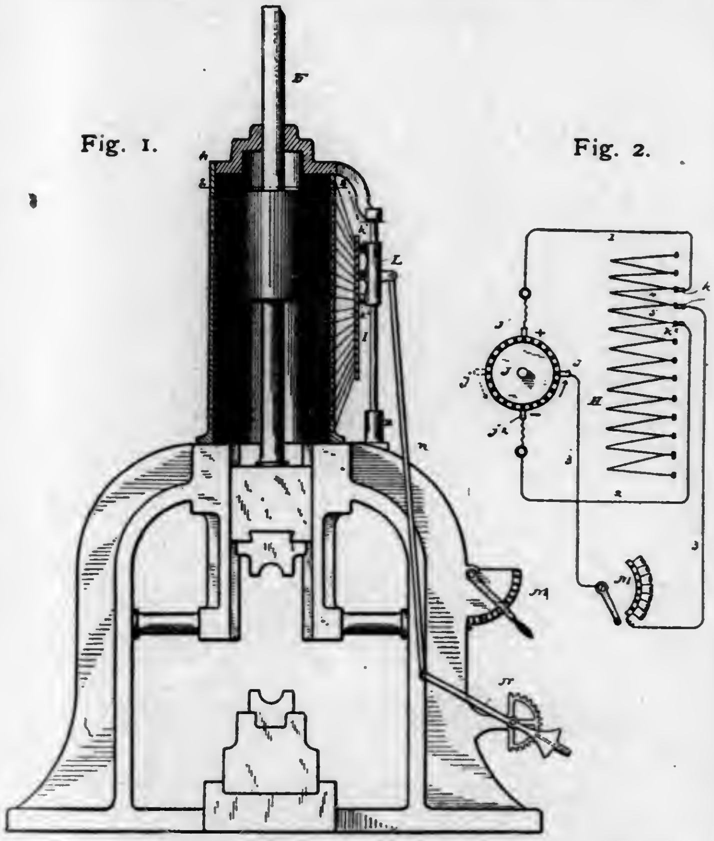
The Generation of Electricity by the Flow of the Tide.—A French engineer, M. Decœur, has elaborated a project by which he proposes to supply electric power to Paris. He would generate the required electricity by utilizing the flow of the ebb and flood on the coast, and transmitting it to the French capital. For this purpose he intends to construct, near Havre, two large basins joined to each other, into one of which the sea at flood tide flows over a dam, while during ebb it flows out of the other into the sea again. At the inlet and outlet, M. Decœur proposes to erect a number of powerful turbines for transmitting the energy of the water. The mechanical energy thus produced M. Decœur estimates, with a tide of 18 ft., which is the average at Havre, at 6 H. P. per hectare of basin area. He intends parting off, by means of a dam 16½ miles long an area of 7,000 hectares between Havre and Tancarville from the sea and the Seine respectively, and thus creating 42,000 H.P., which power he will transform into electrical energy and transmit to Paris. M. Decœur's scheme is looked upon with favor, and there are indications that it will ultimately be carried out.—*Iron.*

An Electric Power Hammer.—In the operation of power hammers for forging heavy work it is necessary that the hammer shall be able to strike directly upon the anvil or at any distance from it within the range of its stroke. To carry out this object in connection with an electric hammer, Mr. C. J. Van Depoele employs the well-known construction shown in the engraving, fig. 1, which consists in the operation of an iron piston acted upon by a series of coils, which raise and lower the hammer according to the position of the switch governing the current passing to the coils. The special object of the construction adopted, however, is to obtain the range of motion. The piston reciprocates continually during the operation of the machine in a constant but changing field of force, within which it may be said to float, rising and falling in accordance with the rise and fall of current above and below it, and, by moving the shifting field of force to any desired part of the motor-coils, the position in which the piston and connected parts will reciprocate can be changed at will and a blow delivered wherever desired—that is to say, the hammer can be made to strike directly upon the anvil or any distance therefrom within the limit of the coils.

The manner in which this is effected will be readily understood by reference to the diagram, fig. 2. Here *J* is a sectional commutator representing a source of continuous current; j^1 j^2 are the main positive and negative commutator-brushes, which are fixed upon the line of commutation; *j* is a moving commutator brush, the office of which is to cause the supply-current to rise and fall in the motor-coils by being moved around the

commutator toward and away from the points of maximum and zero electromotive force. The brush, j^1, is connected with a contact-brush, K^1. The commutator-brush, j^2, is similarly connected with a brush, k^2, and the moving brush, j, is connected with a brush, k. The brushes, $k\ k^1 k^2$, are secured in a fixed relation to each other in an insulated carrier, L, fig. 1,

Fig. 1. Fig. 2.



and maintained in contact with the commutator, i. With the positions shown in fig. 2 current would flow through brush j^1, brush k^1, into coil 4, through coil 5, out through brush k^2, and back through brush j^2 to the commutator, J. The moving brush, j, being in central position, and, therefore, conveying no current in its travel about the commutator toward and away from the fixed brushes, will cause the current to fall in one of the motor-coils and rise in the other, and so on, so long as the brush, j, is kept in motion, it being apparent that the current which is continually rising and falling in the motor-coils is constant in direction and maintains a field of force which is gradually shifted back and forth between the coils in circuit with the brushes, $k\ k^1\ k^2$; from which it follows that the piston, G, will move within the active coils, no matter in what part of the machine they may be. The current, never being interrupted or broken, the piston will therefore float within the coils without being able to escape in either direction. The speed at which the brush j is moved will determine the rate of reciprocation of the plunger, G, and in order to most conveniently regulate the power of the apparatus an adjustable resistance, M, is connected in the circuit, as shown.

As a convenient means of conveying current through the circuits, the brushes $k\ k^1\ k^2$ are, as stated, mounted in fixed relation to each other in a movable carrier L which is sustained in front of the commutator I. In order to vary the stroke of the piston the brush-carrier L is adjusted up or down by means of a latch-lever N and a connecting-rod. The lever N is located in a position convenient to the workman operating the machine, and the adjustable resistance M is also located in convenient proximity.

Increasing Traction by Electricity.—Experiments are now in progress on the Baltimore & Ohio Railroad with the system of electrically increasing traction, or rather adhesion, devised by Mr. Elias E. Ries and owned by the Ries Electric Traction & Brake Company, of Baltimore. The apparatus is fitted on No. 777, an ordinary eight-wheel passenger locomotive. The traction-increasing current is generated by a small alternating current dynamo driven by a rotary engine supplied with steam from the locomotive boiler. The engine and dynamo are mounted upon a common base secured to the boiler in the position formerly occupied by the sand box. One or both pairs of driving-wheels are electrically insulated from the body of the locomotive and from each other by the use of special insulation surrounding the driving-box and side-rod brasses. The insulation so far employed has proven itself fully capable of withstanding the exceptionally severe strain to which it is subjected, and tests made after several months of continuous service have led to its permanent adoption for this class of work.

Electrical connection with the two pairs of drivers is maintained by means of peculiarly constructed brushes bearing upon brass sleeves secured to the central portion of each driving axle. These brushes are connected, by means of heavy stranded copper conductors, with the source of low tension current, which in this case is a transformer placed in proximity to the main driving-axle. A type of machine is now about to be used, however, which generates directly the low-tension quantity currents required. As the resistance of the traction-increasing circuit is practically constant under given track conditions, the flow of current is usually regulated by varying the electro-motive force, which, on account of the low resistance of the circuit and multiple connection of the driving-wheels, can be kept very low. The current density at the points of contact between the driving-wheels and rails can be varied at will, according to the percentage of increased adhesion desired, the usual range being from 500 to 2,500 amperes.

It is proposed to use part of the current generated by the dynamo, either directly or indirectly, according to the type of machine employed, for the operation of electric locomotive and train brakes, electric headlight and train lighting, etc., in addition to its use for increasing traction. The dynamo is generally kept running at a slow rate of speed when not otherwise employed, and is so constructed as to respond promptly and automatically to any demand that may be made upon it within the limits of its capacity.

It is claimed that the tests so far made show that the adhesion of a locomotive of ordinary weight can be increased fully 25 per cent. by the Ries apparatus.

Electric Street Railroads.—According to figures compiled recently there are now nearly 9,000 miles of street car track in this country and Canada. The figures furnished by the *Street Railway Journal*, in response to an inquiry, are as follows, being derived from the latest returns received from street railway companies:

Miles of Horse railroad	5,902
" " Electric "	1,753
" " Dummy "	556
" " Cable "	441
Total mileage	8,652

There are now in operation 44 cable roads and 264 electric roads. The total number of street railroads is about 1,000, so that the lines operated by electricity include about 25 per cent. of the roads and about 20 per cent. of the total mileage. This is an excellent showing for the comparatively short time that electricity has been in use on railroads.

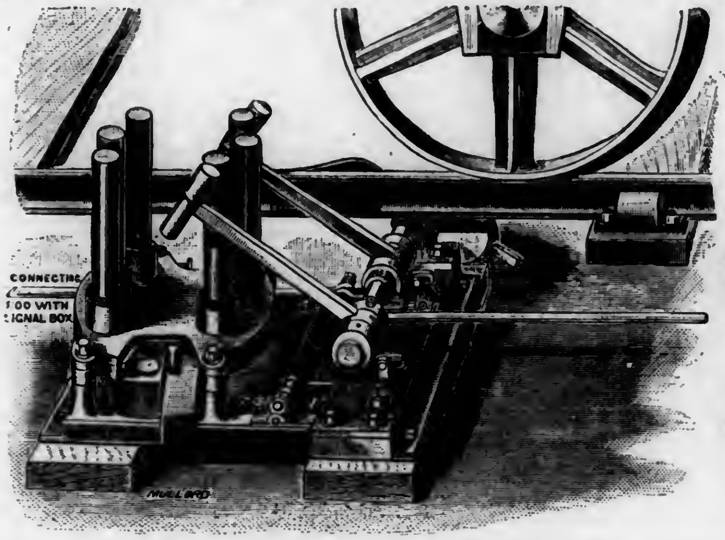
It is no wonder that the problems of street railroad work are so attractive to electrical inventors and electrical engineers. They begin to realize the magnitude of the field, its possibilities, and the fact that it is theirs in a peculiar and special way. It is also a good training school for the heavier work that awaits beyond in operating many of the present steam railroads.

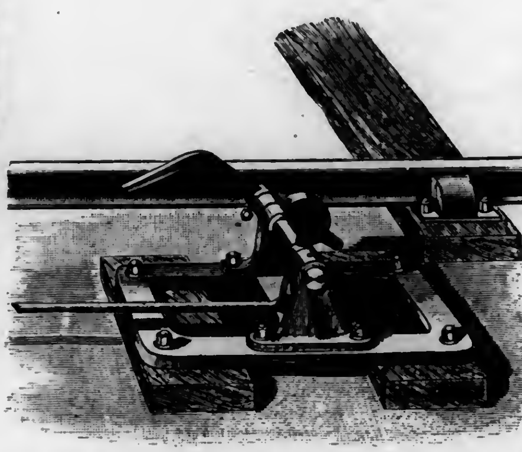
The work of the street railroads in the urban transportation of our people is enormous. In St. Louis it has been found that the whole population is carried 110 times a year by the street cars. In the State of New York the surface street railroads, 91 in number, carried 368,496,648 passengers during the year ending September, 1889, or the whole population of the State 50 or 60 times. If we added the 217,000,000 of the elevated roads, it would make the population of the whole Empire State ride not less than 80 or 90 times a year in the street cars. Probably such high ratios do not apply over the whole country, but the figures are still very striking, even if minimized. There are slightly over 29,000 street cars, open and closed, in America. If, say, 18,000 of these are in daily commission and carry no more than 200 passengers each, the total number of passengers is not less than 1,314,000,000 per annum. This would give every inhabitant of the United States about 20 car rides a year.

Evidently street railroad work is rapidly assuming gigantic proportions, and as it grows it opens up a larger and larger area for electrical engineering and electrical productions.—*Electrical Engineer.*

A New Incline Railroad.—An incline railroad for passenger traffic, built on Cameron Hill, in Chattanooga, Tenn., is described in a paper recently read before the Engineering Asso-

ciation of the Southwest. This road is owned by the Chattanooga Water & Power Company, and was designed and built by Messrs. Guild & White, Civil Engineers, in that city. It was opened for traffic in October last. The road is a double-track line of three rails, with a fourth rail at the center passing point. The incline is 1,495 ft. long, rising 300 ft., the minimum grade being 1 per cent.; the maximum, 31 per cent., and the average grade, 20 per cent. The car floors and seats are built to be level at the average. The cars, two in number, are attached by permanent grips to opposite sides of the 1-in. hauling cable, which passes through the driving machinery at the top of the incline. This machinery has to be reversed at the end of every trip. The alignment is straight except for 100 ft. of 6° 40′ curve to the left ascending, and 150 ft. of 10° curve to the right. The gauge of the track is 4 ft., and the length of the ties for double track is 12 ft. The rails are laid directly on stringers 7 in. × 12 in. in size and 16 ft. long, which are bolted to the tops of the ties, in order to give room for the cable conduit on those portions of the lines occupying city streets. The cars have a seating capacity of 30 passengers, and can be stopped at any point by electric signals from the conductor to the engineer at the power station, these signals being transmitted through an overhead wire with which connection is maintained by a traveling trolley projecting from the top of the car. To insure the prompt starting of the descending car, which may have been stopped on the nearly level portion of the line, a $\frac{5}{8}$-in. tail-cable





passes from each car to the foot of the incline, around the tension sheaves, and returns to the other car, thus attaching both to an endless cable, whose direction of motion is reversed for every trip. The slack of the cable is taken up by a movable tension carriage at the foot of the incline, which works against stiff springs, and has a travel of about 3 ft. Provision for holding the cars in the event of a break of the cable includes a sector brake-shoe, which falls under the wheels and into which the wheels roll, forcing down a V-shaped grip upon the rail-head. Trials of this brake show that it will hold the cars motionless on the steepest portion of the incline. To prevent danger from possible over-winding, the upper extension of each track ends in a level piece of track, the end of which is on level ground, from which the cars cannot return to the rails unaided. The trip over the incline occupies about three minutes.

Photography in War.—A writer on this subject in *Broad Arrow*, alluding to the reproduction of dispatches intended to be sent by carrier-pigeons, says that in this branch no sensible progress has been made since the siege of Paris, during which the French employed photography to this end with surprising ingenuity and completeness, and we cannot perhaps do better than quote what was written on the subject by the French savant, Gaston Tissandier:

"No one can have forgotten the service rendered by balloons during the siege of Paris, nor the wonderful part played by carrier-pigeons, which brought to the besieged city news from the outer world. But these birds, however strong they might be, could only carry with them very light burdens through the air. A thin sheet of paper two or three inches square was all the load that could be intrusted to these winged messengers. But how write orders, send dispatches, give precise instructions in such a minute letter? The most able caligrapher could hardly make it contain the letters in a single page of a printed volume. Microscopic photography came to the assistance of the besieged; it solved the difficulty as no other art could have done; it reproduced on a film of collodion weighing less than a grain more than three thousand dispatches, that is to say, the amount of sixteen pages of folio printed matter. . . . Several of these films, representing a considerable number of dispatches, were rolled and enclosed in a quill about the size of a toothpick. This light and novel letter-box was attached to the tail of a pigeon. . . . Each pigeon could carry 20 films in a quill, the whole not weighing more than 15 grains. . . . Thirty or 40 copies of the microscopic despatches were usually printed and sent by as many pigeons. More than 100,000 of them were thus sent to Paris during the siege. As soon as the small tube was received at the telegraph office, MM. Corun and Mercadier proceeded to open it with a knife. The photograph films were carefully placed in a small basin of water, in which were put a few drops of ammonia. In this liquid the dispatches unrolled themselves. They were then dried and placed between two plates of glass. It then only remained to lay them on the stage plate of a photo-electric microscope."

Automatic Fog Signal.—The accompanying illustrations show a fog signal apparatus devised by Robert Adams and Stanhope A. Say, of London, which is now being introduced in England. Fig. 1 shows the apparatus arranged at the side of the track, and fig. 2 is the distant arm.

As will be seen from fig. 1, two sets of three turrets are arranged on an iron foundation, each cylinder being capable of containing 40 cartridges, or 240 in all. These detonators are placed in the vertical cylinders by hand, and in actual working are passed into annular spaces at the bottom of the chamber by the arms of a horizontal disk, which revolves on a vertical axis. To the latter is fixed a ratchet wheel, which is revolved by means of a pawl, which is connected with the rod communicating with the lever in the signal-box. Thus, on the signalman pulling over the lever, the pawl is released, and the ratchet wheel turns the distance of one tooth, the horizontal disk also making part of a revolution. This causes a cartridge to be placed on each of the two anvils, one of which only is shown in the illustration. Of these anvils, one is arranged on the left-hand and the other on the annular chamber, in open spaces of which they are fixed. Sufficient space is left for the reception and expulsion of the exploded cartridges, the latter being effected by the arms of the horizontal disk.

There are two hammers which partly revolve on the shaft shown. These hammers are raised by a pull of the signalman's lever and are held in position by a pawl. Simultaneously with the lifting of the hammers two elbow levers, placed close and almost in contact with the rail, are raised. One of these levers is shown near the portion of the wheel in fig. 1, and the other in fig. 2. The first lever is fixed on the shaft on which the hammers turn, while the second lever or distant arm is mounted upon a second shaft (fig. 2), placed at any suitable distance away, but close to the same rail, and connected by a rod to a loose lever working on the hammer shaft. Thus, on a train passing over the elbow lever, they are depressed sufficiently to detach the pawl holding the hammers in their raised position. The hammers, being released, fall with great force and explode the cartridges. The spent cartridges are removed, and the hammers and elbow levers again raised to their usual position by the signalman pulling over the lever in the manner already explained. When the apparatus is worked from the signal-box the same levers which are used in connection with the semaphores can be arranged for the double purpose.

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NEW YORK, NOVEMBER, 1890.

OWING to the pressing engagements of the Author in connection with the meetings of the Institute of Mining Engineers and the Iron & Steel Institute, the regular installment of Practical Railroad Information is this month omitted. In its place there will be found the paper read by Dr. Dudley before the British Iron & Steel Institute at its New York meeting, on the Wear of Metal as Influenced by its Chemical and Physical Properties; a paper which is in itself a valuable contribution to practical knowledge, and so finds an appropriate place in our series, though it comes a little out of its due course.

THE remains of Captain John Ericsson, which were carried to Sweden by the cruiser *Baltimore*, were received in that country with appropriate honors, and have found their final resting-place in the graveyard at Filipstad, in the province of Wermland, close to the spot where the great engineer was born. The coffin is deposited in a mortuary chapel built for the purpose.

It may be noted that the railroad over which the coffin was carried from Stockholm to Filipstad was located and built under the direction of his brother, Nils Ericsson, who held high rank in Sweden as a civil engineer.

LATEST advices from China are that the Viceroy Li Hung Chang has completed arrangements for the extension of the Tientsin-Kaiping Railroad to Kisin. The immediate object of the new line is rather military than commercial.

There is in China a growing fear of Russia, especially in view of the probable early construction of the Siberian Railroad, which will connect the Pacific Coast settlements with European Russia.

The new Chinese railroad extension will run from Kaiping toward the northeast, passing through the northeastern portion of the province of Chih-li, then through the province of Sheng-Ching and on to Kisin, which is the capital of the province of the same name, bordering on Siberia.

The exact course of the road is not yet known, but it will probably pass through Shan-hai-Kuan, Niu-chuang and Moukden. It is expected that the road will be unprofitable for some years, but as it will pass through a very fertile but now sparsely populated region, it will prove profitable in the end by developing the provinces of Sheng-ching and Kisin.

The funds for the new enterprise have been borrowed from European capitalists, a loan of 20,000,000 taels at 4½ per cent. interest having recently been negotiated.

THE production of pig iron in the United States for the year ending June 30, 1890, according to the statistics collected by the Census Office, was 9,579,779 tons (of 2,000 lbs.); an increase of 153 per cent. over the census year 1880. Iron was produced in 24 States, and the changes in different sections are well shown by the following table, taken from the preliminary report:

DISTRICTS.	Year Ended May 31, 1870.	Year Ended May 31, 1880.	Year Ended June 30, 1890.
New England States.. ..	34,471	30,957	33,781
Middle States...........	1,311,649	2,401,093	5,216,591
Southern States.	184,540	350,436	1,780,909
Western States...........	522,161	995,335	2,522,351
Far Western States.......	....	3,200	26,147
Total	2,052,821	3,781,021	9,579,779

The most remarkable growth here shown is in the South, where the development of the iron industry has been rapid during late years. Thus Alabama, which is now the third iron producing State, was tenth in 1880, while Virginia has risen from seventeenth to sixth.

As to fuel, the comparative statements show a small increase in charcoal furnaces, and a considerable decrease in those using anthracite coal, the great gain in production being made by the furnaces using bituminous coal and coke. It may be noted that in 1890 nearly 44 per cent. of the whole production was Bessemer pig iron.

The change in methods is well shown by the fact that while the increase in pig-iron production in 10 years was 153 per cent., the number of furnaces in 1890 was 562, against 681 in 1880—a decrease of 17½ per cent. This is due to the abandonment of many of the old furnaces, which have been replaced by larger ones; expressed in another way, the average output per furnace (counting all completed) has risen from 5,552 to 17,046 tons a year—the average furnace of 1890 has over three times the capacity of that of 1880. This, however, is not at all exact, since probably a larger proportion of furnaces were in blast last year; but it is an approximation, and shows the change that has taken place.

THE question of the building of the Quaker Bridge Dam has been reopened by a report recently submitted to the New York Aqueduct Board by Chief Engineer Fteley. In this report he states that careful investigations have been made with regard to the underground formation of the Croton Valley above and below the location recommended for the Quaker Bridge Dam, the general result being to show that the rock underlying the valley forms a deep trough, the bottom of which is from 60 to 108 ft. below the river bed. This trough is filled with drift composed of hard-pan and boulders, with here and there compact sand. While additional storage is undoubtedly needed, and there is at present a great waste of water which runs over the

old Croton Dam in rainy seasons, Mr. Fteley is, in light of all the facts collected, not prepared to recommend the building of a dam on the site recommended by the engineers at Quaker Bridge. Two alternative propositions are submitted in the report, the first being for the building of a dam at Cornell's, 1¼ miles above Quaker Bridge, which would be about 1,736 ft. long, and where the rock is at considerably less depth than at Quaker Bridge. The second point indicated is designated as "Location 2," a little less than a mile below the Croton Dam. Here the length of the dam required would be only 995 ft., and the height above the river 100 ft. The size and location of the dam needed at this point is such that it could be in part an earth embankment, and while the storage capacity of the reservoir formed by its construction would be somewhat less than half that of the Quaker Bridge Reservoir—16,000,000,000 galls. against 34,000,000,000—the cost would be considerably less than half. It is thought that the storage capacity would be ample for the needs of the city for at least the next 20 years; probably for a much longer period when it is supplemented by the building of the proposed new reservoirs in the water-shed of the Upper Croton.

To sum up the reasons for recommending a dam at the new site, they are that it can be built in much less time, say three years instead of six; the land to be taken is of much less area: the necessity of building two costly bridges and several new roads is avoided; the dam being of less height, risks of accident and delay would be much less, and finally the cost would be much smaller.

With the construction of this proposed dam the total storage available, including the present reservoirs and those under construction, would be over 50,000,000,000 galls., or more than 200 days' supply for the city.

A STRIKING paper on the Protection of Iron and Steel Ships was read at the Pittsburgh meeting of the Iron & Steel Institute by Sir Nathaniel Barnaby, an eminent authority on shipbuilding in England. While finding much fault with present systems of construction for their imperfection, he claims that size is in itself an element of safety, and he believes that in the future the mastery of the seas will be gained by the building of ships of far greater dimensions than any which we have yet reached. Such a ship, say 1,000 ft. in length and perhaps 300 ft. in breadth, with engines of at least 60,000 H.P., would be practicable, and could be made almost absolutely secure against ordinary marine disaster, and Sir Nathaniel believes that it might be constructed before many years had passed, startling as the idea may now seem to us.

THE plans for the three new battle-ships have been somewhat modified by the Navy Department. The principal change is an increase of 16 ft. in the length and of nearly 700 tons in displacement, so that these vessels will be 348 ft. in length and 10,000 tons displacement with an ordinary load, which may be increased when they are carrying coal for a long cruise. It is believed that the model will be so improved that a speed of 15 knots an hour can be obtained without any material increase in engine power.

The increased displacement will be utilized in great part by putting on additional armor, extending the water-line belt, and increasing the thickness of the casemates and the shields provided for the 8-in. and 6-in. guns. The change will not alter materially, however, the general design of the ships, but will, it is believed, somewhat increase their capacity and effectiveness.

ON another page will be found the last of a series of articles on the Development of Armor in modern warfare, which are appropriately brought to a close by an account of the latest armor tests at Annapolis. This series of articles, which has included guns and armor—the methods of attack and defense above ground or above water—will be completed by an account of submarine mines and projectiles. Torpedoes are a subject about which much has been said, though but little has been done with them in actual warfare.

THE Annapolis armor trials, to which reference is made on another page, seem to establish the excellence of our naval guns, whatever conclusion may be reached as to the armor-plates. The gun shop at the Washington Navy Yard has now been developed into an establishment where work of the highest class can be not only thoroughly, but quickly done. This may be of very great importance to the country, and it is to be hoped that future appropriations will permit a proper increase of the plant and efficiency of the shop.

THERE is to be no diminution of activity in the Lake shipyards this winter. The various yards at Buffalo, Cleveland, Toledo, Detroit, Bay City and Duluth are all busy, and the contracts already placed, according to the *Marine Review*, include 29 steamships and 5 steel barges, having a total capacity of 81,600 tons. Seven of the steamers only are to be of wood; the remaining 22 will have steel hulls. Nearly all of them are large vessels, as may be seen from the total tonnage reported. Besides these other contracts are pending, which will probably bring the total up to over 100,000 tons.

THE Portage Lake Canal, originally a private enterprise, is to be sold to the Government, and will, with its connections, be widened and deepened, furnishing a channel for the largest vessels, and enabling them to avoid the detour around Keweenaw Point, the most dangerous piece of navigation on Lake Superior. The works purchased include two canals, one 5 miles in length and connecting Portage Lake with Lake Superior on the east, the other 2½ miles long and making the connection to the westward. The price to be paid by the Government is $350,000, and a considerable amount must be spent in dredging and deepening the channel through the lake.

UNDER the act passed at the last session of Congress authorizing the letting of contracts for guns for the Army, the Chief of Ordnance has called for bids for 100 new guns, 25 to be of 8 in., 50 of 10 in., and 25 of 12 in. caliber. They are to be of the types provided in the specifications, but the kind of steel and the methods of manufacture will be left to the contractors. The lengths and weights are to be: 8-in. guns, 32 calibers length of bore, weight 14½ tons; 10-in., 34 calibers, 30 tons; 12-in., 34 calibers, 52 tons. The proposals will be received until December 18. The guns will be subjected to very severe tests as to quality of metal, range, accuracy, and endurance.

TESTS of steel, and the causes of delay in delivering material for the new ships under contract, were discussed

at a conference held at the Navy Department in Washington recently, at which were present representatives of the firms now building ships for the Navy, and the firms which are supplying the steel. Some relaxation in the strictness of the tests was asked for, but no action has been taken as yet.

EVOLUTION IN THE LABOR QUESTION.

THAT the relation of laborers to their employers is in a state of evolution is indicated by a pamphlet recently issued by the managers of the New York, Lake Erie & Western Railroad. This contains a communication from the federated body of employés of that road composed of engineers, conductors, firemen, and trainmen, who say that they respectfully submit to the manager "the following schedule of pay and regulations to govern said employés, to which we expect a just and satisfactory answer, within a reasonable length of time." Then follows a schedule consisting of 83 distinct articles "to govern said employés." These relate to the rate of pay, hours of work, duties, promotion, suspension, passes, leave of absence, etc., of the employés.

To this petition the President of the Company has made a respectful reply, explaining fully why most of the requests could not be granted. A review of the reasonableness or unreasonableness of the 83 articles would occupy more space than can now be devoted to this subject, but the aspect of the case to which especial attention is called, is the calm and apparently reasonable way in which the requests of the men are presented, and the just and fair consideration which they have received. The attitude of both sides is expressed in scriptural language, "Come now, let us reason together." This certainly is very much better than that assumed by the manager of a Western railroad about twenty years ago, when waited on by a committee of the men who had "grievances" and were met by the reply that "they should go to hell." On another occasion, when a strike was defeated, a division superintendent telegraphed with great glee that "The Brotherhood of the Foot Board has been crushed." At that date the idea of "crushing" trades unions was very generally entertained. The pamphlet before us shows how much more rational the attitude now is, which the managers and the men have assumed toward each other. It should be kept in mind by both sides, however, that the basis of all this is "sweet reasonableness," and that when either side makes unjust demands, the other—to quote Scripture again—is quite sure to say, "Should a wise man utter vain knowledge and fill his belly with the east wind? Should he reason with unprofitable talk? or with speeches wherewith he can do no good?"

Some of the requisitions of the employés of the Erie system and the recollection of unreasonable demands which have from time to time been made elsewhere, lead to the suggestion that the employés would usually strengthen their cause very much if they would employ some competent and wise lawyer in formulating their demands. The presentations of the employés' side of the labor question are not usually models of English composition. A good lawyer would not only express their side of the question better than it usually is, but by his advice they would often be prevented from falling into the serious error of making claims which in their nature are unwise or which would lead to violations of the law.

The pamphlet issued by the managers of the Erie system is evidence that the idea of crushing or eradicating trades unions is, at least in some quarters, not entertained any longer, and that it is wise for both men and managers to discuss questions in dispute between them like rational human beings rather than to fight it out like savages.

BRITISH AND YANKEE LOCOMOTIVES.

THE discussion of this subject by our cisatlantic and transoceanic contemporaries seems to have reached the profane stage represented by a well-known picture of a loquacious bird and a mischievous quadruped, in which the one is plumeless and the other has been curtailed. As evidence of this, the language of the purveyor of American engineering news may be quoted. In a recent number our contemporary says: "The discussion (was) closed so far as we are concerned in our issue of September 27, ... as it is quite useless to carry on a technical discussion with an antagonist who will not even truthfully state the positions and arguments which he is opposing."

This language is not flattering to the other disputant and is not characterized by "sweetness," nor does it indicate that the author is in a frame of mind which would be receptive of "light." Although his mental vision, so far as this subject is concerned, seems for the time to be somewhat obscured, yet from the fact that he has published the comments on this subject, which appeared in the last number of this JOURNAL, he is evidently still able to recognize a source from which light emanates. In an introductory way he says: "Our lively contemporary"—meaning us—"makes answer to one of the points raised by the *Engineer*, which is so apt and to the point, and withal so amusing, that we cannot forbear quoting it." We regret that it is impracticable to print this page on pink paper, to be indicative of how such complimentary language effects our complexion.

In his introductory remarks to the reprint, of what first appeared in these columns, he puts in a sort of claim for priority by adding "that we perceived *this* to be one of several points in which our English contemporary's positions were very vulnerable, as will appear from a quotation given below." It is not easy to tell what "*this*" refers to. The only construction that can be put on the language is that by "this" is meant "one of the points raised by the *Engineer*," the weakness of which was pointed out in the article which the *News* reprints. Before doing so the editor takes occasion, however, to remark that "we perceived this," but considered it "quite useless" to say so. There are occasions which arise in discussions of this kind, when the only comment which can be made is expressed by an exclamation mark. This seems to be such an occasion.

The use of exclamation marks is also demanded on reading his comments on the article which our contemporary has republished. He says that "we distrust our lively contemporary's figures above, in so far as they appear to show higher evaporations than some 700 lbs. per square foot of grate, a certain error resulting from the assumptions made in regard to average speed, probably." Then follows an extract from a book which the editor of the *News* is the author of, in which the dictum is expressed that "ordinarily it is not possible to evaporate more than 600 lbs. of water per square foot of grate per hour,

. . . and 500 lbs. of water per square foot of grate would come nearer to a moderate working maximum."

We confess our inability to comprehend the nature of a "certain error" which is "probable" or of a "moderate maximum," and will leave the subtle author of the book quoted from to struggle with the metaphysical distinction involved in such expressions, but when he speaks of "assumptions in regard to speed" a total and absolute denial is the only reply to be made. Such "assumptions" are the result of his imagination. There were none. The speeds given in our article were taken by careful observers and were given on the authority of the Superintendent of Machinery of the Grand Trunk, the Baltimore & Ohio, and the New York Central & Hudson River Railroads.

Furthermore, the context where the assumed error in regard to speed is pointed out, and the writer's quotation from his book is given is suggestive. What is said is in effect "we distrust our lively contemporary's figures." In my book it is written differently. Surely "lively" is not the adjective which would properly describe a state of mind capable of producing such a potential syllogism—*viscid* would be better.

The discussion and the conclusions reached by the disputant on the other side of this discussion, in which we occupy the position of a commentator, may be briefly summed up. Some time ago the *Engineer* said that "the whole discussion turns on whether a locomotive boiler has to generate more steam in a given time in America than in England." In an article on Mr. Barrus's tests of Vauclain's compound locomotive, built at the Baldwin Locomotive Works, which article was published in the *Engineer* of September 19, the Editor of that paper says: "The running time (of the Vauclain engine) was six hours, and in that time there was burned 16,389 lbs. of coal. As the grate area was 25 square feet, a very simple calculation shows that the rate of combustion per square foot of grate per hour was over 109 lbs. *We have nothing in England to equal this. About 75 lbs. per square foot of grate per hour may be regarded as a maximum consumption with our fastest and heaviest expresses.*" In our article, already referred to, it was shown that on the Hudson River Railroad during 66 runs of 143 miles each 119.6 lbs. of coal was burned per square foot of grate per hour. On the Grand Trunk 121.6 lbs. and on the Baltimore & Ohio in one case in a test of an hour's duration on their 17 mile grade, they burned 133.2 lbs., in another 148.1, and *in a third* 193.7 *lbs. of coal per square foot per hour.* The experiments on the latter road were made by the present Superintendent of Machinery of that line, and are vouched for by him. It is not easy to emphasize this evidence sufficiently. If we can burn more than twice as much coal in our locomotives as can be burned on those built in England, we are in a position to proclaim the fact to the world. Our builders can now say to railroad companies in Australia, in India, in South America, and, in fact, everywhere, that they can furnish locomotives which will do nearly or quite twice as much work as is done by English engines of like weight. The admissions of the *Engineer* and the evidence submitted by THE RAILROAD AND ENGINEERING JOURNAL now seem to make this certain.

In the beginning of this article we ventured to intimate that some of the feathers of one of the disputants in this controversy were missing, and the posterior ornament of the other had been lessened. As we occupy the position of a commentator only, neither party is obliged to reply to our comments, but if, with the evidence which has been submitted, our English contemporary remains silent about it, there will be additional grounds for the conclusion that so far as the capacity for burning coal and generating steam is concerned, the superiority of American locomotive boilers has been proved, and that our simile of the parrot and that "amoosing little cuss," as Artemus Ward described the other figure in the picture referred to, has not been misapplied. Regarding the question whether under like circumstances, or with moderate train loads, and the same quality of coal, English engines would be more economical than ours, no evidence has been submitted. It is to be regretted that the feelings, as well as the feathers, of one of the disputants in this controversy have been so ruffled as to lead him to declare that, "so far as they are concerned," they won't play any longer. There are still many questions in dispute which have not been touched and which interest engineers the world over. The discussion has not only been amusing, but it has educed the important fact that American locomotives can and do burn a great deal more coal and generate more steam in a given time than English engines can or do. This fact has never been brought out so clearly before. In view of this it is to be regretted that our American contemporary has allowed his angry passions to rise, because if the discussion was continued and a little side light was thrown on it by independent commentators, it might be equally productive in other directions. Besides, we hoped that both parties to the controversy might be induced to adopt our suggestion, and each design a locomotive for comparison and criticism. If they did then the discussion would certainly be entertaining.

WORLD-RAILROADS.

SOME interest was taken a few months ago in certain trips around the world, undertaken to show in how short a time the journey could be accomplished. The time actually made by existing railroad and steamship lines was 73 days; and this could be reduced by three or four days under favorable circumstances and with prompt connections.

Taking these voyages as a text, M. Weissenbruch, Engineer to the Belgian Ministry of Railroads, in a recent note published in the *Bulletin* of the International Railroad Congress, shows how this time may be diminished, and also how it is within the limits of possibility, and is even probable, that within a few years the traveler will be able to make the journey from London to New York by rail.

Three great transcontinental lines—or, as the Germans would call them, world-railroads—are projected in Asia. The first of these is the line from Constantinople to Bagdad, and thence by way of the Tigris Valley, the Persian Gulf, and through Belouchistan to a connection with the Indian Railroad system on the Upper Indus. While a beginning has actually been made on this, actual work has been limited to some 90 miles, from Scutari to Ada-Bazar, in Asiatic Turkey, and it is not likely to advance very rapidly until economic conditions in Turkey are materially changed, and English capital can be largely drawn in that direction.

The second is the so-called Grand Central Asiatic line,

proposed by M. Cottard, a French engineer, and M. de Lesseps. This would start from Orenbourg, in Russia, run through Western Siberia and Tartary to a connection with the Trans-Caspian line at Tashkend, and thence by Samarkand and Kabul to Peshawur, in Upper India. This is purely a paper project, with no present prospect of construction, and is interesting only as a remote possibility.

The third line is the Great Siberian Railroad, of which some account has already been given in our columns ;* and this is the only one of the three which can be said to be under actual construction. The first and most difficult sections are well advanced toward completion, and there is little doubt that when the great plains of Southern Siberia are reached, it will be pushed forward steadily ; perhaps even there may be a repetition of the extraordinary work which called such wide attention to the building of the Trans-Caspian Railroad, under General Annenkoff.

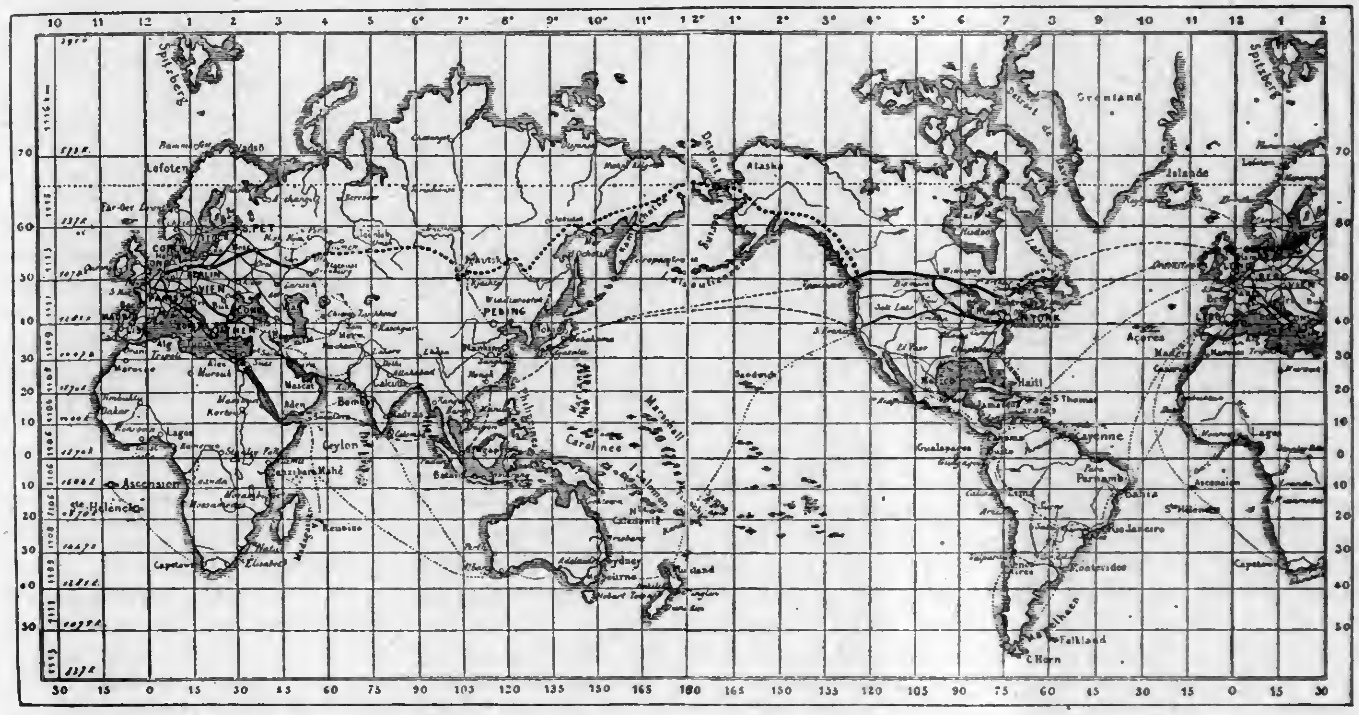
The objective point of the Siberian Railroad is Vladivostok, which is only 920 nautical miles from Yokohama ; and it will readily be seen how much its completion will shorten the time required to circumnavigate—if that term can properly be used for a journey made half by rail—the globe.

But the Siberian Railroad is destined, M. Weissenbruch thinks, to have two great branches. The first will pass through Kiahkta into China, and in time to Pekin ; but this, while commercially of great importance, will not be part of the world-railroad. The greater branch will start from Nertschinsk or Albasin, on the Amoor River, and will run northeastward, skirting the Okotsk Sea, and crossing Kamchatka to Behring's Straits ; there to meet what, for want of another name, we might call the Alaska Central & Atlantic line, which would run from Behring's Straits southward to a connection with the Canadian Pacific at Vancouver, and with the Northern and the Southern Pacific at Tacoma and Portland.

The bridging of Behring's Straits presents no serious obstacles ; nor would it be more difficult to run a railroad in Kamchatka and Alaska than in the north of Sweden or in some parts of Russia, where lines are already worked successfully.

The possibilities may be extended indefinitely ; the International line, connecting North and South America, may be completed, and in that case the traveler might take his "through sleeper" in London, Paris or St. Petersburg, not only for New York, but for the City of Mexico, Rio de Janeiro, Valparaiso, or Buenos Ayres.

Further, it has been proposed to build a railroad from Quebec to Bay St. Charles, on the coast of Labrador, the nearest point on the American Continent to Europe, from which steamers could make the voyage to Liverpool inside of 4 days. Supposing an average speed on the railroads of 40 miles an hour—which is not impossible—the trip around the world could then be made in 23 days.



The accompanying sketch map, although on a very small scale, will be sufficient to show M. Weissenbruch's idea of the route. As to the time which it will take to realize this idea, he can best speak for himself as follows :

> But, it will be said, how much time will be required before all these works can be accomplished ?
>
> The railroad system of the world has to-day a total length of about 606,000 km. (376,568 miles), and its average increase—very slightly variable for the last period of 10 years—may be taken at 24,000 km. (14,913 miles) a year.
>
> Now to connect London and New York by rail it is necessary to build only 15,800 km. (9,818 miles) of road, an amount much less than this yearly increase.
>
> Supposing only the building of 1,000 km. (620 miles) of the road yearly ; in 15 years the projects of which we have spoken will be accomplished facts, or on the point of becoming so.

All this may seem visionary now ; but in view of the wonderful developments which many of us, who are not old men yet, have seen with our own eyes, who will venture to say that in 15 or 20 years from now the starting of the "through St. Petersburg, Paris and London express" from New York will seem a less wonderful event than the departure of a through train for San Francisco did less than 25 years ago ; or that we will not start on the rail journey of 16,200 miles to London with fewer misgivings

* See the RAILROAD AND ENGINEERING JOURNAL for June, 1890, page 258 ; for September, 1890, page 403, and in the present number, page 503.

than our fathers felt less than 60 years ago, when they entered the cars for a trip from New York to Philadelphia.

THE THAMES RIVER BRIDGE.

Report to the General Manager of the New York, Providence & Boston Railroad upon the Construction of the Thames River Bridge and Approaches at New London, Conn. By Alfred P. Boller, Chief Engineer, New York.

The title of this volume indicates its general character, but to give an idea of its form and scope some description is needed. It may be classed as a pamphlet of 60 pages, $10\frac{1}{2} \times 14$ in. in size with 13 folded plates and tables. The printing and paper are all that could be desired. Besides the lithographed plates there are also a number of half-tone engravings of rather inferior quality. The size and form of the volume calls for the same criticism as that which was given last month in noticing the catalogue of the Hall Signal Company—the pages are too large for convenience, and the lines, although the type is treble-leaded, are too long to read comfortably. All the engravings, excepting the first one, would have gone on a page half the size, and as the plates must be folded in any event, an additional fold would not have injured them.

The bridge is built over the Thames River at New London, Conn. The river is in reality an arm of Long Island Sound and was formerly crossed by a ferry some distance below the location of the bridge. The cars of the New York, Providence & Boston Railroad were run on the boat and a whole train was taken over at once.

The greatest depth of water at the bridge site was 57 ft. and below this was an unstable bottom in which piles had to be driven, which was attended with much difficulty. The method of doing this and constructing a foundation is fully described and illustrated in the plates and engravings, but the description could have been more easily understood if there had been more reference to the engravings. As it is the reader is left to himself to find the engraving which illustrates what is described in the text, which is often a very blind search. These are, however, minor faults in an otherwise excellent description of a great work.

The history and location of the bridge are fully described in the first pages. Then follows an account of the method of constructing the foundations, and the special difficulties which were encountered and the way they were overcome. Next a description of the masonry follows and of the settlement of the piers.

The bridge itself consists of a central draw of 503 ft. span measured from center to center of outside piers. There are then two through spans, symmetrically disposed one on each side of the draw-span. These consist of two trusses on the Whipple system 45 ft. deep at center for three panel lengths, thence sloping downward on either side at the rate of 5 ft. to the panel to the end posts, where the trusses are 25 ft. deep, a form of construction conducive to economy by reducing the sheer in the web system, to say nothing of a more sightly appearance than would result from trusses of a uniform depth throughout. Outside of each of the through spans is a deck span 20 ft. deep and designed on the triangular system, and composed of five panels 24 ft. 8 in. long with intermediate posts supporting the upper chords.

The swing-span, with the same depth of truss at the ends as the adjacent fixed spans, slopes upward toward the center, where it attains a height of 71 ft., two-fifths the slope on either side of center being in a parabolic curve, the balance being a straight incline. This symmetrical disposition of the trusses and their form, especially that of the draw-span, gives the bridge a peculiarly graceful appearance. The æsthetic features of the structure have evidently been studied as well as its purely engineering features. It is gratifying to know that the design is not only graceful and pleasing, but that it is also economical. The excuse for making structures hideous and unsightly is that it would be too expensive to make them otherwise. As a matter of fact the ugliness of bridges is due generally to the absence of a sense of beauty or grace in their designers. In the present instance the Engineer of the Thames River Bridge was an artist as well, and as a result both the engineering and the artistic effects are good and neither was sacrificed for the other, and, in fact, the science of the engineer seemed to improve the work of the artist, and *vice versa*.

The description of the difficulties and the methods of sinking and forming the foundation will be interesting to all engineers engaged in similar work. The illustrations of these and of the superstructure of the bridge are excellent. The mechanism for opening and closing the draw-span and the signal system for guarding the bridge are given at considerable length. These are followed by a summary of the cost, which was for right of way, \$325,214.42 ; construction of approaches, \$254,189.87 ; superstructure, including bridge, masonry foundations, and testing, \$658,489.50 ; general account, including engineering, inspection of steel, etc., \$56,046.12, making a total of \$1,293,939.90.

Specifications of the superstructure and foundations are also given, with elaborate tables showing the results of the tests of materials are given. It should be added that the material used was chiefly "Open Hearth" steel with a breaking strength of not over 65,000 or 68,000 lbs. per square inch, but some Bessemer steel was used for the compressive members. The whole report is a valuable addition to the literature of bridge engineering.

NEW PUBLICATIONS.

PRACTICAL BLACKSMITHING: COMPILED AND EDITED BY M. T. RICHARDSON. VOLUME III. New York ; published by M. T. Richardson (illustrated ; price, \$1).

Like the previous volumes of this series, this book is a collection of articles contributed at different times to the *Blacksmith and Wheelwright*, which have been carefully edited and put together in accordance with a definite plan. Volume I of the series dealt chiefly with shop plans, forges and chimneys, with some articles on the early history of blacksmithing. Volume II treated of tools, while Volume III, the present one, finishes the subject of tools and then goes on to describe methods of doing a great variety of the jobs which are likely to come to the blacksmith in the course of his every-day experience. The chapters under the latter heading include Welding ; Steel and its Uses ; Forging Iron ; Chain Swivels and Plow Work.

Under each of these headings we find a number of notes. For instance, in the chapter on Forging Iron there are given several methods of forging a valve-yoke ; several for making eye-bolts, T-irons and a variety of wagon and locomotive work. All these are illustrated, and the directions are generally practical and to the point.

The articles generally have been written by practical men, and describe methods of work approved by experience. The book, while not an exhaustive treatise on metal work, contains much that is of practical use, and a blacksmith can hardly read it without getting information which should be of value to him in his work.

A fourth volume is promised, which will complete the series.

PROCEEDINGS OF THE TWENTY-THIRD ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION, HELD AT OLD POINT COMFORT, VA., JUNE 17, 18 AND 19, 1890: EDITED BY ANGUS SINCLAIR, SECRETARY. New York ; published for the Association.

The Report of the Master Mechanics' Association has been brought out this year by Secretary Sinclair with his usual

promptness. It covers a convention of somewhat more than usual interest, in which some points of importance were discussed. Perhaps the portions which will be most read and referred to will be the reports and discussions on Compound Locomotives and on the Link and other Valve Motions. The action taken which will interest many members is the appointment of a committee to arrange for bringing the yearly convention and that of the Master Car Builders' Association closer together. A new subject appears in the appointment of a committee to report next year on Electrical Appliances bearing on locomotive construction and management—a field which will probably continue to widen with each succeeding year.

A Year's Naval Progress: Annual of the Office of Naval Intelligence. June, 1890. Washington; Government Printing Office.

This publication is No. IX of the General Information Series prepared by the Office of Naval Intelligence in the Navy Department, and is, as its title purports, a record of the year's progress in naval development abroad. The object is to preserve a record of this progress for future reference and for the present information of our own naval officers.

The range of subjects covered is shown by the following list: Ships and Torpedo-boats; Machinery; Ordnance and Armor; Applications of Electricity; Naval Manœuvres of 1889; Ministries of Marine and *Personnel* of European Navies; Merchant Marine in Foreign Countries; Rapid-fire Guns; Liquid Fuel for Torpedo-boats; Manœuvring Distance of Steamers; Automobile Torpedoes. There is also a chapter on the development of our home resources for the production of war material.

The work has been carefully and thoroughly done, and this year's volume will bear comparison with its predecessors very well. It contains a great body of information on naval matters, intelligently arranged and presented. Special interest attaches, perhaps, to the chapters on Applications of Electricity and on Torpedoes, since those are subjects now attracting much attention.

Trusses and Arches Analyzed and Discussed by Graphical Methods. Part I, Roof Trusses: by Charles E. Greene, C.E., Professor of Civil Engineering, University of Michigan. New York; John Wiley & Sons (price, $1.25).

This is a revised edition of a book which has already met with a good reception, both as a text-book in technical schools and as a book of reference for designers. In this edition the general arrangement has been improved, and some additional problems have been added.

It is hardly necessary now to speak of the increased use and acceptance of graphical analysis for the solution of problems, or of the advantages which the graphical methods present. The book before us is a clear presentation of the problems involved in the subject of which it treats, and the simplest and most direct methods of solving them; of finding the stresses and devising methods of designing trusses for roof work.

Instruction Book of the Westinghouse Air Brake Company. The Quick Action Automatic Brake. Pittsburgh, Pa.

The above Company has just issued a very neat book of instructions concerning the use of the air brake. It is of the pocket-book form with a flap and a pocket containing four sets of engravings which show the construction of the brake, and two cards with transparent gelatine sections of the engineer's valve to show its action more clearly than it can be shown by ordinary engravings.

The Instruction Book contains 63 pages of text, and begins with a general description of the brake which is followed by descriptions of the air-pump, the triple-valve, the engineer's brake, and equalizing discharge-valve, the pump governor, general arrangement of the brake. All of these chapters refer to the brake for passenger trains. This is succeeded by a description of those parts of the brake for freight cars which differ from those for passenger cars. The concluding portion relates to the arrangement of levers, the power of the brake, and the distance in which trains may be stopped.

A book of this kind has been very much needed, and the want has been admirably filled by the publication before us. It is bound in morocco, and with the exception of the printing of some of the excellent engravings, the work is very well done. The life of the large sheets of engravings, in the hands of some of the people for whom the book is intended, will, it is to be feared, be a short one.

In addition to the Instruction Book the Westinghouse Company have also issued a pamphlet of eight pages, the same size as those of the book, with the title "Don't.' It tells persons who use the brake what not to do, and is excellent in its way.

Buff & Berger's Hand-Book and Illustrated Catalogue of their Engineers' and Surveyors' Instruments. No. 9 Province Court, Boston.

This is a book of 150 pages with about half that number of engravings of the instruments made by that firm, with descriptions of them and directions for their care and use, and is a treatise which every engineer who has occasion to use such instruments should read.

In the August number of the Journal we published a "note" read before the Institute of Mining Engineers, by William P. Blake, on the Use of Aluminum in the Construction of Instruments of Precision. As this subject is attracting a good deal of attention, and as there are some popular misapprehensions regarding the subject, the following extract from Messrs. Buff & Berger's catalogue will be of interest, especially as it is the expression of the views of practical instrument makers. They say:

> We believe, in the present state of its development it is not a suitable material for precision instruments. . . . The disadvantages are that pure aluminum, although very rigid, is nevertheless a very soft metal like tin, but when alloyed with 20 per cent. or 30 per cent. of copper, it becomes so brittle as to break like glass."

The volume is what its name implies, a "hand-book," and an excellent treatise on the care and use of field instruments.

Catalogue and Price List of Engineering Specialties Manufactured by the Curtis Regulator Company; Boston.

This is a small pamphlet issued by the above company and describes the various articles which they make, consisting chiefly of pressure regulators for both steam and water, expansion traps, steam traps, damper regulators, combined separators, and traps. The construction of these is all described and they are illustrated with very neat engravings. The pamphlet is so small that it can readily be carried in the pocket, and contains a great deal of information which is interesting and useful to those who use the appliances described. The only criticism that suggests itself is that the type is rather small for those of us who have passed our semi-centennial, and who are condemned to the constant companionship of spectacles.

BOOKS RECEIVED.

Reports of the International American Conference: 1. On an Intercontinental Railroad Line. 2. On Postal and Cable Communications with Central and South

AMERICA. 3. ON AN INTERNATIONAL MONETARY UNION. 4. CONCERNING A PLAN OF ARBITRATION FOR THE SETTLEMENT OF DISPUTES BETWEEN THE AMERICAN REPUBLICS. 5. MESSAGE OF THE PRESIDENT OF THE UNITED STATES AND LETTER OF THE SECRETARY OF STATE TRANSMITTING REPORTS AND RECOMMENDATIONS. Washington ; Government Printing Office.

TRIPLE-EXPANSION ENGINES AND ENGINE TRIALS : BY PROFESSOR OSBORNE REYNOLDS, LL.D. EDITED BY F. E. IDELL, M.E. New York ; the D. Van Nostrand Company (Science Series, No. 99 ; price, 50 cents).

ANNUAL REPORT OF THE COMMISSIONER OF DAMS AND RESERVOIRS OF THE STATE OF RHODE ISLAND. L. M. E. STONE, COMMISSIONER. Providence, R. I.; State Printers.

REPORTS OF THE CONSULS OF THE UNITED STATES : BUREAU OF STATISTICS, DEPARTMENT OF STATE. NO. 118, JULY, 1890. Washington ; Government Printing Office.

TRANSACTIONS OF THE WAGNER FREE INSTITUTE OF SCIENCE : VOLUME III. CONTRIBUTIONS TO THE TERTIARY FAUNA OF FLORIDA : BY WILLIAM HEALY DALL, A.M., PALEONTOLOGIST TO THE U. S. GEOLOGICAL SURVEY. Philadelphia ; published by the Wagner Free Institute of Science.

ANNUAL REPORT OF THE OHIO & MISSISSIPPI RAILWAY COMPANY FOR THE YEAR ENDING JUNE 30, 1890. Cincinnati, O.; issued by the Company.

THE IRON AND STEEL SCHEDULE OF THE NEW TARIFF LAW : THE NEW RATES COMPARED WITH THE OLD. Cleveland, O.; issued by the *Iron Trade Review*. This pamphlet will be exceedingly convenient to all interested in the iron trade. It is clearly printed, in type of a good size.

TEIKOKU DAIGAKU (IMPERIAL UNIVERSITY OF JAPAN) : CALENDAR FOR THE XXII-XXIIID YEAR OF MEIJI (1889-90). Tokyo, Japan ; published by the University.

SLOW-BURNING CONSTRUCTION : WITH TABLES OF SAFE LOADS UPON BEAMS : BY C. J. H. WOODBURY. Boston ; issued by the Manufacturers' Mutual Fire Insurance Company.

ANNALI DELLA SOCIETA DEGLI INGEGNERI E DEGLI ARCHITETTI ITALIANI ; 1890, FASCICOLO IV : ING. C. C. BARAVELLI, SEGRETARIO. Rome, Italy ; published by the Society.

AIR ENGINES : ILLUSTRATED DESCRIPTION AND ACCOUNT OF TESTS. Boston ; issued by the Woodbury, Merrill, Patten & Woodbury Air Engine Company.

COMPOUND LOCOMOTIVE ENGINE AND SUBSTITUTE. Paterson, N. J.; issued by H. A. Luttgens. This is a description of Mr. Luttgen's patent locomotive smoke-stack damper.

THE IRON, STEEL AND ALLIED INTERESTS OF JOHNSTOWN : FOR THE INFORMATION OF THE VISITING MEMBERS OF THE FOREIGN AND AMERICAN TECHNICAL SOCIETIES. Johnstown, Pa.; published by the Local Reception Committee.

THE WESTINGHOUSE AUTOMATIC BRAKE : ILLUSTRATED CATALOGUE, 1890. Pittsburgh, Pa. ; the Westinghouse Air Brake Company.

ABOUT BOOKS AND PERIODICALS.

AMONG the articles in BELFORD'S MAGAZINE for October will be found one on Irrigation and Legislation, by R. J. Hinton, which has a direct practical application just at present. There are other articles of much interest, including a sketch of the late Matthew F. Maury, who did so much for Hydrographic science.

The resources of the new State of Washington are summed up in the first article in the OVERLAND MONTHLY for September. This is a historical number, in which the leading articles are on Fremont, by J. C. Davis ; Who was the Pathfinder ? by H. L. Wells, and the Beginnings of California, by F. I. Vassault. The Pious Fund of California is a note of a little known episode in the early history of the State.

Among the articles of interest in the POPULAR SCIENCE MONTHLY for October are Irrigation in China, by General Tcheng Ki Tong ; Cotton Spinning North and South, by H. V. Meigs ; Ancient Dwellings of the Rio Verde Valley, by Dr. E. A. Mearns ; Barrier Beaches of the Atlantic Coast, by F. J. H. Merrill. There are a number of others equally interesting, though having less special bearing on engineering topics.

The National Guard of Minnesota is the subject of an article in OUTING for October, which shows how prominent a place the Guard has taken in the West. This series of articles is the work of competent military authority, and both the praise and the criticisms contained should do good. The articles are timely for another reason also, and it is to be hoped that they will arouse that public interest in the National Guard which should be felt in every State.

The articles describing the cruise of the new Squadron of Evolution are continued in SCRIBNER'S MAGAZINE for October, with Mr. Zogbaum's excellent illustrations. Mr. John W. Root tells of the development of the City House in the West, and H. L. Webb has an excellent description of the laying of an ocean cable. Professor Shaler's second article on Nature and Man in America deserves a careful reading.

Mr. Theodore Child's articles on the South American republics are continued in HARPER'S MAGAZINE for October by one on Agricultural Chili, which does not give an altogether attractive picture of the State which we are accustomed to consider the most progressive of our southern neighbors. The First Oil Well is the subject of a paper by Professor Newberry, who dates back the discovery of petroleum some 3,000 years beyond that commonly given.

The Death Penalty ; the Censorship of Morals ; an Endowed Press ; the Race Problem ; Trusts ; Schools and Churches are among the many subjects which the ARENA for October includes in its very comprehensive table of contents. All these topics are handled freely and with no lack of ideas ; the object of this magazine is to bring out discussions on topics of present interest and free expressions of opinion, and so far it has been very successful.

Monographs on important engineering works are among the most valuable contributions to technical literature. Dealing closely with details as they should and generally do, they will often give the student or the engineer an insight into matters which he will seek in vain in larger works, where attention is necessarily given more to general principles. One such work —Mr. Boller's Report on the Thames River Bridge—is referred to in another column. Another, which is now in press and will shortly be issued, is an account of the WASHINGTON BRIDGE over the Harlem River in New York, written by Mr. William R. Hutton, the Chief Engineer under whose charge the structure was built. The proof sheets show that description of this bridge is a very complete one, and it is admirably illustrated, not only by numerous views from photographs, but also by very complete drawings giving all the details of the work. It will be a valuable addition to the library of every bridge engineer. It is published by Mr. Leo Von Rosenberg, of New York.

Our very energetic contemporary, ARCHITECTURE AND BUILDING, on October 4 issued a special number devoted to School-House Architecture—a very timely one in view of the attention just now attracted by the subject. The issue contains 21 new designs by architects who have made school-houses a special study ; it is profusely illustrated, and is in every way a number of especial value.

COLOR-BLINDNESS.

To the Editor of the Railroad and Engineering Journal:

THE popular idea of "color-blindness," as it is called, falls curiously short of the reality; it is common to hear it spoken of as a disease, a state of being to be inherited, and a case for doctors to study, but probably incurable. There is, however, good reason to doubt if this is ever the true description of the matter; on the contrary, there are plausible reasons for considering and treating that which is called color-blindness as a faculty, an accomplishment to be acquired.

And while color is not to be entirely eliminated from the *materia* of signals, the idea of testing a man's eyes in relation to his capacity for distinguishing such signals is richly absurd, and ridiculously foolish.

It is probably true that, while but few ever recognize or practise this faculty with any definite knowledge or thought, the accomplishment is in a greater or less degree almost universal, and a person who cultivates the art sees any particular color or not at will. The fact that color-blindness is often temporary and increases or decreases at different times in the same individual seems to be passed over without notice; and the other fact that the human eye, in respect to the faculty of distinguishing color or light, and conversely darkness, is affected by barometric, hygrometric and thermometric influences, or that motion pure and simple may affect the nerves of the eye in the same manner as light or color, is apparently forgotten; yet probably a sharp blow on the head, especially when near the eye, would, by the simple jarring of the optical nerves, produce the same effect as a brilliant light upon any person—any boy can tell how to make one "see stars." A similar effect may be produced by simple pressure of the fingers upon the closed eyes, and the various stomachic conditions known to produce headaches, or heaviness and dullness of the faculties, find the optical nerves among the easiest to disturb.

A person on a warm muggy evening had occasion to enter a dark room, and suddenly seemed to be enveloped in a diffused light as bright as that of gas; the effect lasted some time, long enough for the observer to note and reason that, as none of the objects known to be at hand were visible, the apparent light, instead of enveloping him, was literally all in his eye, and also to note that, beside the close, heavy atmosphere and a tendency to headache, there was no feeling either painful or otherwise to be connected with the phenomenon; and he experienced a slight regret that, being alone, there was no one to tell him whether his eyes shone like a cat's or not; later observations of such cases made this appear very improbable.

When it is considered that all of color as relating to any one individual is simply different effects produced by different causes upon the nerves of the eyes, it becomes apparent that the same causes may produce different effects. In this respect the nerves of the eye are not so very dissimilar from those of the ear, which it is well known can discriminate such slight variations of sound that when a number of voices sing or instruments play as nearly as possible the same sound, the trained ear will distinguish a single one, and even one at will, to, in a great degree, the exclusion of all others. Thus the eye may be trained and under control so as to select any shade of color and see that both more quickly, more distinctly and more strongly than any other; and the same is true with regard to forms.

A boy, looking up from his book in a room where the wall-paper was of a green on gray, with Prussian blue spots about ¾ in. in diameter and 6 in. apart, saw nothing but the blue spots, the other figures appearing all blank; a repetition of the case arousing his curiosity, he found that by a slight effort he could at any time see the blue spots, banishing everything else, or banish the blue spots and see all of the other colors clearly and plainly. The effort in this case he describes as simply trying, as in case of seeing double, by focusing the eyes beyond the object looked at.

Cultivation of this art will enable the observer to increase or decrease the effect of any color, as in a carpet or wall-paper pattern, and also to substitute their negative neutrals, or in case of mixed shades, to separate, giving extra effect to one or more of the components. Thus orange may be made to appear more red or more yellow not merely by juxtaposition, but by the same effect produced by muscular efforts in the eye itself.

Juxtaposition is one of the most common causes of mistakes in color; some combinations are absolutely painful to the eye, causing it to ache, as when trying to use spectacles that do not fit. Yet the designer of frescoes may be so far color-blind as to take a saucer of green paint for vermilion, and yet the public approve of his labors.

That color may or may not be always seen by the same eyes is a matter not only subject to control by the will, but it is also liable to be affected by habit or association. A person has seen the bright colors of a piece of calico change, while he looked, to their negatives, and for years after found it a matter of effort to ever see those colors in that piece of cloth, although the same colors or combinations were perfectly clear elsewhere; again, the negatives having been seen in the place of the colors in one part of a carpet, the colors may be clear and perfect all over the rest of the floor, yet upon turning the eyes to the same point again, the negatives persistently assert themselves.

In view of these facts, it appears that "color-blindness" is more a matter for the schoolmaster than for the doctor to deal with, and more can be accomplished by instruction and practice than by medicine and surgery.

ALOHA VIVARTTAS.

PISTON ROD BREAKAGES.

(From the *Practical Engineer.*)

TO the practical engineer, one of the most interesting portions of Mr. Longridge's report deals with the particulars of breakdowns of engines insured by his company. These breakdowns may be classified as under:

37 per cent. due to causes purely accidental or unascertained.
18 " " negligence of owners or attendants.
14 " " old defects and wear and tear.
31 " " weakness from faulty design or bad workmanship.

The particular part of the engine to which the damage in each case seemed to have been due, or where the damage was due to something external to the engine, the part which seemed to have broken first, is given in the following list:

	Numbers.		
	During 1889.	During previous 9 years.	Totals.
Spur gearing	20	214	234
Valves and valve gear	25	211	236
Air pump motions	13	140	153
Air pump buckets and valves	8	92	100
Columns, entablatures, bed plates and pedestals	11	67	78
Bolts, screws, jibs, cotters and straps	15	67	82
Main shafts	7	58	65
Parallel motions, links and guides	8	57	65
Pistons	3	35	38
Cylinders, valve chests and covers	3	29	32
Flywheels	2	26	28
Piston rod crossheads	6	25	31
Piston rods	4	23	27
Cranks	1	21	22
Governor gear	1	20	21
Air pumps and condensers	4	18	22
Crank pins	1	12	13
Gudgeons in beams	2	11	13
Beams and side levers	0	9	9
Connecting rods	1	8	9
Total wrecks, cause unknown	0	5	5
Second motion shafts	0	1	1
Main driving ropes	1	0	1
	136	1149	1285

This list points out very clearly the weak parts of mill engines generally, if the engines insured by this company

be, as they probably are, a fairly representative selection, and for this reason it is commended to the attention of millowners and engineers.

To describe all the breakdowns for the year in detail would be impossible; to leave them altogether without comment would be inconsistent with the objects of the company in publishing these reports. A selection, therefore, must be made. Last year spur gearing was considered. This year it is proposed to say something about piston rods and crossheads.

The breakdowns Nos. 26, 38, 126, were caused by piston rods breaking at the cotter-holes within the crossheads, and No. 135 by the breakage of an air-pump rod at the same place. The ends of the rods are shown in figs. 1 to 4 on this page, the position of the fracture being indicated in each case.

Fig. 1 was the wrought-iron rod of a horizontal Corliss condensing engine. The cylinder was 34 in. diameter,

FIG. 1.

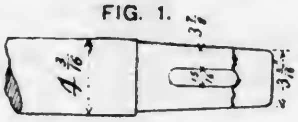


FIG. 2.

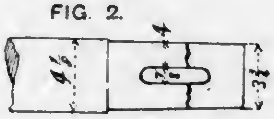


FIG. 3.

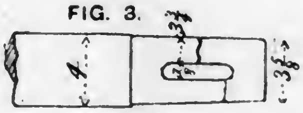


FIG. 4.

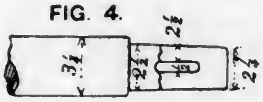


FIG 5.

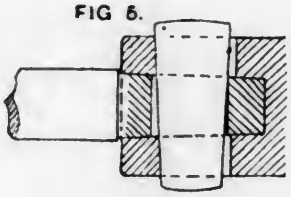


FIG. 6

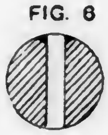


FIG. 7.

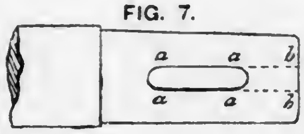


FIG 8.

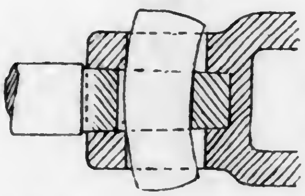


FIG 9

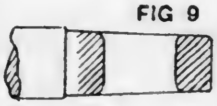
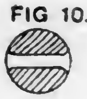


FIG 10.



the stroke 5 ft., the speed 43 revolutions per minute, the maximum effective pressure from 60 lbs. to 65 lbs. per square inch, and the point of cut-off about $\frac{1}{5}$ of the stroke. The maximum load upon the rod was, therefore, from 55,000 lbs. to 60,000 lbs. The sectional area of the fracture was 5 square inches, so that the stress per square inch, if uniformly distributed, would not have exceeded from 11,000 lbs. to 12,000 lbs. The rod was put in new in March, 1883 and a new cotter was fitted in January, 1889. In March, 1889, the rod gave way, having been subjected to about 87,000,000 applications of the stress since it was put in, and to about 3,000,000 since the new cotter was fitted. It is said that the rod was sound when the new cotter was put in.

Fig. 2 was also the wrought-iron rod of a horizontal Corliss engine; diameter of cylinder, 36.3 in., stroke of piston, 5 ft., revolutions per minute, 40, maximum effective pressure, 50 lbs. per square inch, point of cut-off about one-tenth of the stroke. The load upon the piston was therefore about 51,000 lbs., and the stress upon the rod, if uniformly distributed over the fractured section, a little over 8,000 lbs. per square inch, the sectional area of the fracture being about 6.6 square inches. The rod and cotter were put in in 1872, and had therefore been subjected to about 230,000,000 repetitions of stress alternately tensile and compressive.

Fig. 3 was a steel rod of the same size and shape as fig. 2. The engine in this case was a horizontal Corliss engine; cylinder, 32½ in. diameter, stroke, 5 ft., revolutions, 39 per minute, maximum effective pressure from 60 lbs. to 65 lbs. per square inch, point of cut-off from one-eighth to one-tenth of the stroke. The sectional area of the fracture was about 6.6 square inches, and the stress upon this area due to the steam pressure from 8,000 lbs. to 9,000 lbs. per square inch. The rod was put in in 1882, and a new cotter in 1886; it had, therefore, sustained 92,000,000 applications of the load since it was new, and 40,000,000 since the new cotter was fitted, the stresses being alternately tensile and compressive. The new rod which replaced it has since given way at the same place, after making only 6,500,000 strokes. This rod was of the same dimensions as the old one, but of iron.

The rod represented in fig. 4 was, as has been stated, an iron air-pump rod. The pump was vertical, 24 in. diameter by 3 ft. stroke, and the bucket made 39 strokes per minute. Taking the pressure on the bucket at the moment when the head valve opened at 20 lbs. per square inch, the stress per square inch of fractured area would be 3,200 lbs. The rod had worked since 18—, but had had a new cotter about the year 1882. It had, therefore, borne a tensile stress of about 3,200 lbs. per square inch, 92,000,000 times altogether, and 46,000,000 times since the new cotter was fitted.

For the sake of clearness the intensities and number of applications of the stresses borne by these rods are tabulated below:

Description of Rod.	Intensity of Stress.		No. of Applications of Stresses.	
	Tensile.	Compression.	Tensile.	Compression.
	lbs. per square in.	lbs. per square in.	Millions.	Millions.
Fig. 1. Iron piston rod ..	11500	11500	43½ altogether.	43½ altogether.
" " ..	"	"	1½ after fitting new cotter.	1½ after fitting new cotter.
Fig. 2. Iron piston rod ..	8000	8000	115	115
Fig. 3. Steel piston rod..	8500	8500	46 altogether.	46 altogether.
" " ..	"	"	20 after fitting new cotter.	20 after fitting new cotter.
" Iron rod replacing steel rod	"	"	3¼	3¼
Fig. 4. Iron air-pump rod	3200	....	92 altogether.	....
" " ..	"	....	46 after fitting new cotter.	.. .

Now, why did these rods break? Had the materials of which they were made been broken in a testing machine, the iron would probably have been found to possess a tensile strength of about 50,000 lbs., and the steel of about 70,000 lbs., per square inch. Even under the conditions under which they were placed—subjection to constant repetitions of stress—our present knowledge would lead us to suppose that the iron piston rods would have withstood stresses of about 17,000 lbs. per square inch, and the steel of about 23,000 lbs., for a very great if not indefinite number of applications, while the air-pump rod, in which the stress was practically only in one direction, would have borne about 30,000 lbs. But these stresses are greatly in excess of the stresses upon the broken rods if uniformly distributed. It would, therefore, seem either that the average stresses upon the rods were greater than has been stated, or that the stresses were not uniformly distributed, but were of greater intensity at some points of the cross-sections than at others. As regards the piston rods the latter was probably the case; as regards the air-pump rod, it is possible that the stress may have considerably exceeded that obtained by dividing the load by the area of the rod, because the load on an air-pump rod is suddenly ap-

plied and is frequently of the nature of an impulse. But there is little doubt that in this case also, fracture was, to a great extent, the result of concentration of stress at one particular point. In each case the fracture commenced at the edge of the cotter-hole, and extended gradually across the rod until the latter was so much weakened as to break off short. This seems to indicate the cause. Consider figs. 5 and 6, and imagine what would happen if the cotter were driven up. Clearly, the whole stress would be borne by the small, sharp-edged bit of rod shown shaded in fig. 6, and would attain a great intensity. Imagine, further, that the conical part of the rod was not an exact fit in the crosshead, but was tighter on the left side than on the right. What would follow on driving up the cotter? Clearly this: The stress, instead of being distributed between the two shaded areas, would be concentrated upon the left-hand one, especially with square-edged cotters. Even supposing the cotter to be a perfect fit in both rod and crosshead there will still be a greater stress along the edges of the cotter-hole than elsewhere; for, in the first place, if the draw of the cotter be resisted by a shoulder on the rod, or by the larger end of the conical part, the whole pressure of the cotter (no slight one if the cotter have little taper and be driven hard), as well as the stress from the steam pressure, will come first upon the layers of material (marked *a a* in fig. 7) which form the sides of the cotter-hole, and these layers will, in consequence, be stretched more than those outside them. If the rod end butt against the crosshead, the part between the layers *a b* will be compressed more than those outside by driving up the cotter, but *a a* will still bear the burden of the load upon the engine; and thus, in either case, the strain in these layers will be greater than in the other parts of the rod.

In the second place, the strain will be greater at the outside edges of these layers than in the middle, because the tendency of the cotter when driven up is to bend to the shape shown in fig. 8, and consequently to bear hardest at the outside of the rod.

Lastly, there is the possibility of the slides not running in exactly the same horizontal plane as the rod, or of the slide bars wearing, and so bringing a bending movement upon the rod, which, if the rod were not a tight fit in the crosshead, and if the cotter were driven vertically, would throw a heavy stress upon the top and bottom fibers of the layers *a a*, fig. 5.

Seeing, then, how many possibilities there are of distributing the average load upon a rod unequally, and of intensifying it enormously at the outside edges of the cotter-hole, the conclusion that these rods broke from excessive stress localized at the edges of the cotter-holes seems not unreasonable. The remedy appears to be to round off the edges of the cotter-holes, as shown in figs. 9 and 10, and thus increase the area by which the maximum intensity of stress must be resisted, to butt the ends of the rods against the crossheads, and to drive the cotter in a plane at right angles to the plane in which the connecting-rod moves. As to the form of the end of the rod itself, it is perhaps a question whether it should be conical or cylindrical, but there can be no doubt as to the propriety of dispensing with the shoulder shown in figs. 1 and 4. Perhaps the better plan would be to make the rod end cylindrical of the same diameter as the working part, and to bush the crosshead when the rod requires turning down.

At all events, there can be no doubt that the utmost care should be taken in fitting the cotters, and that cotters showing signs of working loose should never be driven up without careful examination of the ends of the rods. Moreover, the writer's opinion is that the sectional area at the cotter-hole should be sufficient to reduce the strain to about two tons per square inch, unless there be good reason for the contrary.

Fig. 4.

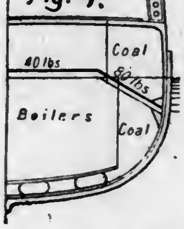
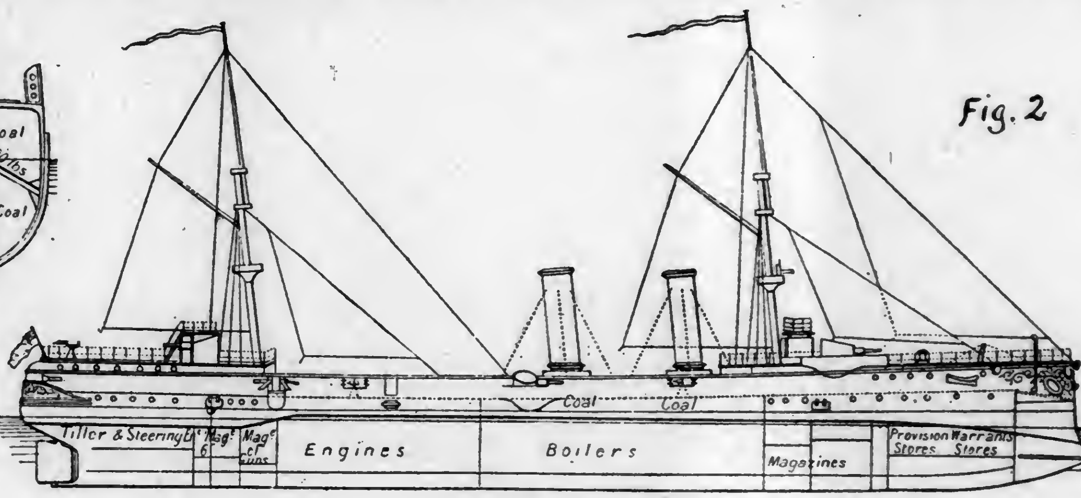
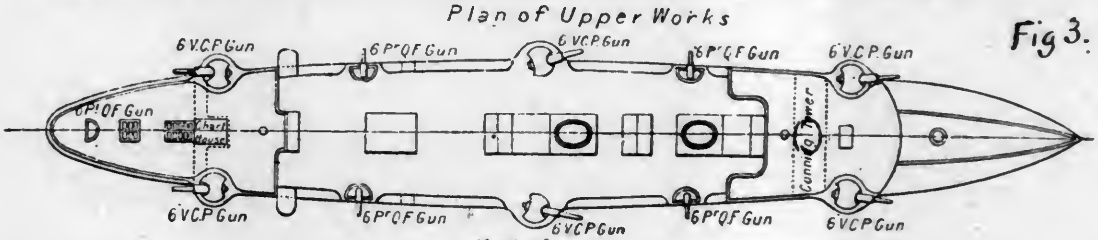


Fig. 2



Plan of Upper Works

Fig 3.



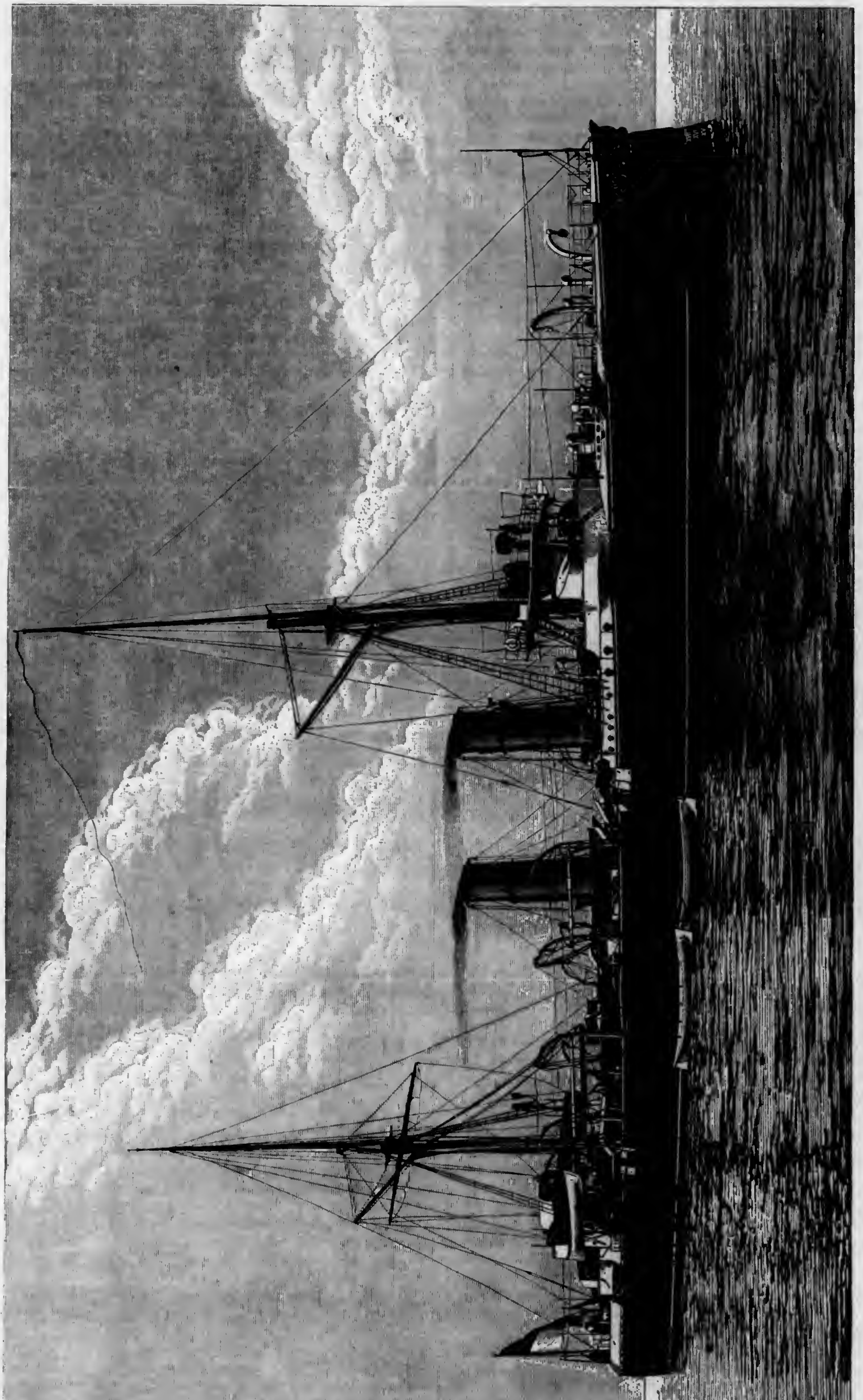
Midship Section

AN ENGLISH FAST CRUISER.

(From the London *Engineer*.)

THE accompanying illustrations show the English cruiser *Medusa*, the large engraving being a general view, taken from a photograph; fig. 2, a side view showing the general arrangement of the ship; fig. 3, a deck plan, and fig. 4, a half cross-section, showing the arrangement of the coal bunkers, etc.

The *Medusa* belongs to a distinct type, entitled the "*Medea* class," which first consisted of five vessels only, but has subsequently, under the new Admiralty programme, developed into an extensive *genus* with increased size and various modifications. It embraces many new features in design and construction, and represents an auxiliary arm to the fighting line, consisting of heavy armored battleships alone; just as of old, the swift frigates were necessary adjuncts of the great line of two and three-deckers. As the five cruisers of the group alluded to are similar in most respects, it appears convenient to describe them generically. They are the *Medea*, *Medusa*, *Melpomene*, *Magicienne* and *Marathon*. The first two were



SECOND-CLASS STEEL PROTECTED CRUISER "MEDUSA," BRITISH NAVY.

built at Chatham, the *Melpomene* at Portsmouth, and the two last-named in the yard of the Fairfield Shipbuilding & Engineering Company at Govan, Glasgow. The vessels are alike in their dimensions and in their internal arrangements, but the constructive materials and engines are different. The *Medea* and *Medusa* are built entirely of steel, and their displacement tonnage is 2,800 tons. Their engines are placed vertically, with inverted cylinders. They were designed to realize a speed of 20 knots; and for the purpose of showing at what an enormous expenditure of energy these high speeds are attained, it may be mentioned that the *Medea*, with a displacement of 2,800 tons, is fitted with engines of substantially the same indicated H.P. as the 16½-knot armor-clad *Collingwood*, with a displacement of 9,500 tons, or between three and four times the weight. The engines are of the twin-screw triple-expansion type, with cylinders of 33½ in., 47 in. and 74 in. respectively, and a stroke of 39 in., and are under the protection of the sloping armor deck. In the case of the *Marathon, Magicienne* and *Melpomene*, the steel hulls are sheathed with wood and copper to enable them to remain afloat for long periods in any climate, without having their bottoms fouled, and their speed consequently reduced. This sheathing increases the displacement to 2,950 tons, and the speed was, consequently, expected to be reduced by about ¼ knot, or to be 19¾ per hour. Even in view of this slight loss of speed and the additional first cost which such an arrangement involves, the change of plan is acceptable, as it gives these cruisers an additional advantage over ordinary vessels, enabling them to remain at coaling or other stations for a long period, and to be afterward available for speedy employment without the necessity of entering a dock in which to have the bottom cleaned. The wood sheathing consists of two thicknesses of teak, making together a thickness of 6 in. The inside layer is attached to the steel hull by iron bolts, and the outside one by bolts of gun-metal. The bottom is further covered with sheets of copper nailed to the teak.

As showing the difference caused by fouling of the ship's bottom, it may be stated that with a rough bottom 5,800 H. P. gave a speed of only 16.9 knots, while when nearly clean the same power gave 17.6 knots an hour. At a speed of 13 knots, 2,000 H. P. were required when the ship was foul, while 1,600 H. P. were sufficient with a clean bottom.

The ram, stem, stern and rudder posts, and the brackets for supporting the twin screws of the sheathed *Medeas*, are all cast in solid bronze, these castings together weighing for each ship about 45 tons.

For protection the vessels depend principally upon a 2-in. steel deck, worked into the framing and extending from stem to stern. This deck is turtle-backed, having a declivity at bow and stern, and along the sides of the vessel. The top level of the deck, in the center of the ship, is about a foot above the water-line, and the declination all round makes the connection of the deck with the sides of the ship at a point about 5 ft. from the water-line. Under this deck are placed the propelling engines and the machinery for working the ship—all the vital parts of the mechanism—as well as the magazines. The coal bunkers are arranged above and below the deck, in that part of the vessel where the engines, boilers, etc., are situated, so that additional protection may thus be secured. While on this subject we may mention that, at the experiments with the hull of the *Resistance* last year, it was found that the filled coal bunkers absorbed more of the energy of high explosive shells which succeeded in effecting penetration, than any other form of protection adopted. The *Medeas* have a double bottom on the cellular principle for carrying water ballast. The immense advantage of these double bottoms has been conclusively proved quite recently. When a heavy shell fell to the bottom of the *Howe*, it pierced the inner skin. Had there not been a second skin the vessel's safety might have been endangered. Similarly, the *Temeraire* was only saved by her double bottom when in collision with the *Orion*. The interior of the hulls of these vessels is divided by bulkheads into ten main water-tight compartments, two of which are occupied by engines and two others by boilers. These four have no doorways between the spaces, but in some of the other bulkheads there have been fitted doors workable either at the door or from the top deck. In addition, these main compartments are subdivided, especially above the protective deck, there being in all close on 270 water-tight spaces.

The armament consists of six 6-in.—5-ton—breech-loading steel rifled guns, on central pivot Vavasseur mountings, two placed forward, two aft and one on either broadside amidships; ten 6-pounder and one 3-pounder quick-firing guns, three light guns and several machine guns. Six torpedo tubes are fitted on board, all under cover, one forward, one aft and two on each broadside.

Accommodation is provided for about 300 men all told. There are two funnels and two masts. The cost of the *Medusa* and *Medea* was about $430,500 each for ships, and $259,600 each for machinery. The principal dimensions of all the five vessels of this type are as follows: Length, 265 ft.; beam, 41 ft.; draft for sheathed portion, 17.6 ft.; for unsheathed portion, 16.6 ft.; tonnage of first, 2,950 tons; of second, 2,800 tons; coal accommodation for 400 tons, sufficient for 8,000 knots at 10 knot speed.

Some slight modifications have recently been made in the bridges and superstructure of these ships, which were found to be inconvenient. One most fortunate circumstance in regard to them all is that the bow wave, in forming its curves along the sides of the vessel, just clears the sponson projections, which, consequently, do not impede the progress of the ship, as in the *Severn*, *Mersey* and *Thames*.

PREMIUMS TO RAILROAD EMPLOYÉS.

(Paper submitted to the International Railroad Congress at Paris by M. Bela Ambrosovics, of the Hungarian State Railroads.)

ACCORDING to moral and social law, the relations between industrial enterprise and their agents should extend beyond those mutual duties which are stipulated in the written contracts and regulations of service. The latter do not pass the limits prescribed by the idea of fidelity—giving this word a somewhat larger meaning than that of the penal code—and mutual service ends when the belief arises on one side or the other that what is demanded is not a service, but a sacrifice.

Without doubt there are agents whose conscience is scrupulous, either by nature or by education, and whose activity is not satisfied by the legal minimum of work. On the other hand, there are also companies which are generous toward their employés; but in any case sentiment and individual ideas are not sufficently solid bases upon which to act in establishing that principle of mutual concession which is always just, and the application of which is so much to be desired.

It is this desire of appreciating the value of the surplus of care and work resulting from zeal—whether produced by moral or material interest—which has without doubt induced the International Commission to put down in the programme of the Milan Congress the question of the best method of interesting employés of railroads in the financial prosperity of their lines.

This is a very important question for the railroad managements, as indeed are all those which relate to financial success. If they are well managed, in such a way as to satisfy external interests, it is something, but it is also necessary to manage them so as to secure a profit for the enterprise. It is a problem, the solution of which demands in unfavorable circumstances most minute care, deep study, and especially practical sense developed upon a solid theoretical basis and by long experience.

At the Milan Congress the question was not discussed in its full extent. Only the question of premiums for economy was considered, while that of increasing receipts by the constant watchfulness of agents was not directly discussed, but only incidentally spoken of on my own proposition. The debate only brought out general ideas, and even in relation to premiums for economy the principles were not sufficiently developed. It is therefore necessary to bring up the question again, and for that reason the In-

ternational Commission decided to bring it forward once more at the third session of the Congress.

The Milan Congress reached three conclusions :

1. It recommended in principle the utility of the system which will give to agents who render special productive service some participation in the profits of the enterprise in addition to their regular salary—a personal participation applying the maxim "to each man according to his work."

2. It favored the extension to all branches of railroad service of the system of premiums for economy wherever the regularity and the safety of operation would not be endangered.

3. It recommended a system of premiums on increased receipts for agents who can act to secure an increase of traffic.

It may be said that by these conclusions the Congress favored in principle the solutions presented to attain the desired end, since no other means can be reasonably imagined to interest employés immediately and directly in the profits of an enterprise than payments to those to whom the increase of profit is due. There are only two ways of carrying out this plan : the first by giving a share in savings to those who secure such savings and in increased receipts to those who secure the increase, or, second, by giving a share to the employés of the two classes named of the net profit of the enterprise.

The differences between a system of premiums and a system of participation consists in this : That in the first case the amount of the remuneration is established in advance, while in the second everything is left to the views and generosity of the management. It remains to examine which of those two systems is preferable, and to see how they may be applied.

PREMIUMS FOR ECONOMY.

Concerning premiums for economy, the Milan Congress enunciated the very just principle that the system of premiums ought not to be applied to those branches of the service on which depend the security and the regularity of management. This, I think, ought not to be taken in a too absolute sense, but ought to be extended in this sense, that the system of premiums should be restricted to the service where the work of the employés can be and really is strictly controlled with regard to safety and regularity. Premiums for economy appear then to be desirable under several heads.

1. For all economies in the consumption of materials used in service which do not belong strictly to the management of the road. These are materials for heating, lighting and cleaning offices and places not open to public use ; materials necessary for office work. For these classes of materials, it seems most advantageous to allow a fixed sum to the employés interested, and to divide any saving among them. In this case, in determining the quantity required upon which the fixed sum is to be based, all the circumstances by which these quantities may be influenced should be taken into consideration. For materials necessary to produce motive power, both on the road and in the workshops, and for the care and maintenance of machines—such as fuel, oil, etc.—a fixed allowance for the unit of work seems most to be recommended. It may be noted that, as to economy in locomotive fuel, it is hardly safe to allow premiums on lines with heavy grades, unless a strict control is exercised over the speed of trains, since it is well known that engine-drivers and firemen, to save fuel, will often travel slowly, trusting to make up time on down grades, sometimes without regard to safety.

2. For economy in the ordinary expense of maintaining the substructure of a railroad, the road-bed, drains, ditches, etc.

3. For economy in the ordinary expense of maintaining roads, water-ways, etc., which the railroad is obliged to keep up.

4. For economy in the ordinary expense of maintaining the track.

5. For economy in the ordinary expense of maintaining the buildings.

6. For economy in expenses relating to yard work at the more important stations, and the handling of freight.

To settle the amount of all these economies, the systems vary according to the nature and circumstances of the case. In general the plan to be recommended is to establish as much as possible premiums based on a unit of price reasonably defined for each sort of work. When we consider works where the quantity of work to be furnished or the number of units depends chiefly upon the employés, it is necessary to fix a maximum which must not be passed without special permission, on penalty of losing premiums, or even of fines. It would be possible, however, with a careful control, as far as safety is concerned, to recognize rational economy and to allow premiums separately for saving any materials below the quantity established.

PREMIUMS FOR INCREASE OF RECEIPTS.

When the Milan Congress recommended the system of premiums on increased receipts for agents who could secure an increase of traffic, it was not forgotten that there are many difficulties in realizing this result.

These difficulties are evident. To create traffic it is necessary that the needs of one place should be satisfied by the surplus of another. It is always difficult to estimate the merit of the first discovery of the co-existence of these conditions and the bringing them together so that business is created. It is more difficult yet to estimate the exact co-operation in the production of this double condition. The solution of the question of premiums may be left to proofs of merit furnished by the interested agents themselves, but this proceeding, applied not in exceptional cases, but as a general rule, would probably lead to a certain demoralization among agents, who would be tempted to use doubtful expedients with shippers to the detriment of the railroad.

The strictness of the first rule laid down by the Congress concerning the participation of agents in profits, was modified in the resolution concerning premiums for increase of receipts, according to which such premiums should be established for agents who can act with effect upon the increase of receipts. This leads us to believe that the Congress, while endeavoring to establish a standard which could hardly be attained, has yet desired that its resolution should not be too strictly construed. The question, nevertheless, remains difficult.

We must consider what agents can claim to be able to increase the receipts of a railroad. In the first place it is necessary to exclude all those whose services do not relate directly to the receipts ; that is to say, the employés in those branches of service who are not in contact with the public ; then among the employés who are in the service of receipts, properly so called, those who, by their positions rather mechanical than speculative, or by their subordinate positions, have no opportunity of acting to increase business. It would also be necessary to exclude the employés of stations at commercial and industrial centers. Lastly, it would be necessary to exclude those articles in which the traffic is constant or at least only slightly variable, or, to speak more precisely, those articles the quantity of which carried does not depend at all upon the railroad agents.

Observing these principles each management could designate the agents or the groups of agents who should participate in premiums for increase of business, excluding the articles just mentioned, and could calculate those premiums on a rational basis.

One of the methods of calculation could be as follows : The average difference in the increase of receipts should be established for a short series of years, say from five to seven. To be just, no account should be taken of a very favorable or of a very unfavorable year. The marked differences should be left out and the average of the remaining years should be calculated. The receipts of the last year, *plus* the average increase, should form a basis for the receipts of the following years, due allowance being made for special circumstances. A certain percentage of the difference between the actual receipts and the receipts thus estimated should be divided among the agents. Part of this sum appropriated for premiums might be reserved to reward unusual merit, and for special objects, and it would be well to establish a maximum for the premium—based, for instance, on the fixed salary—which could not be ex-

ceeded. It is hardly necessary to say that those who have shown negligence or idleness should be excluded.

A variation of this system would be to estimate not for a single year, but to establish an average of two or three years, and to make no computation for the premiums until the end of the last year. The difficulties attaining this system are too slight for mention.

This system could be applied according to circumstances to the total receipts on certain classes of freight only; or the receipts of certain articles, the traffic in which cannot be influenced by the activity of agents, might be excluded. The premiums might be divided among all the agents or among groups of agents according to the list of articles.

Following up this point of view the systems could be changed in detail. Thus, premiums could be established not for the increase of receipts, but for the increase in quantity of certain articles shipped, or of certain articles at certain stations; or again, premiums could be paid to agents who brought to the road traffic in articles not before carried, and still other variations might be suggested.

What I wish to recommend in every case, however, is that the agents interested, and especially the heads of stations, should be caused to co-operate in preparing the estimate of receipts and that they should be required to report yearly, or perhaps monthly, on the commercial outlook and the traffic in different articles which should be expected from the activity at their stations. These reports would be valuable, because they would develop the interest of agents in business and would stimulate their zeal and commercial spirit.

It would be well also to require heads of stations to collect statistics relating to the production of articles brought to stations for shipment. These statistics would be a useful element in fixing tariffs.

It would be well in my opinion in establishing such a system to begin with a minimum percentage and afterward to regulate it as experience shows. The agents, led by their own interest, would not hesitate in aiding the management and in securing the establishment of the best method of obtaining the desired end. At the opening of a new line one of the methods mentioned could be applied in estimating the probable receipts, but naturally with much caution. It would seem best, however, to wait for the results of operation at least for the first year.

PARTICIPATION IN PROFITS.

It would be possible under this system to set aside a certain proportion of net receipts and to permit the agents to participate in this in proportion to their merit. They could be also allowed to share in the increase of profit or in the two together. As in the previous system, estimated figures as precise as possible should be established. The point which presents the most serious difficulties, more serious here than under the system described, is the valuation of merit. If, however, the principle "to each according to his merit" is applied strictly, and all agents are excluded who have shown themselves unworthy, this system could be preferred to any other on account of its simplicity.

The point of highest importance, in my opinion, is to lead the employé to identify his personal interest with that of the enterprise, and in consequence to develop in him the commercial spirit in the interest of the road. This is altogether a different thing from leaving the employé to interest himself temporarily in the results of a single branch of the service, and from developing in him a spirit of gain. It is possible to use economy which is injurious to the enterprise. A false economy is wasteful economy, and may produce accidents, the fatal consequence of which would cost more than the saving of several years. It is possible to establish tariffs or make arrangements by which an increase of receipts may be obtained for the moment, but which would be injurious to the development and future extension of traffic. A high rate upon a certain article may, for example, while increasing the receipts of a railroad, cause the shipment of the same article, or of another which could be substituted for it, but from a place situated beyond the system of the road. It may even happen that while the receipts of one system are increasing, the receipts of the whole road will be diminished.

It may be said generally that there is hardly any agent of a road who cannot render to it in one way or another a service in excess of his strict duty. In interesting all in the prosperity of the enterprise, in making them identify themselves with it, each of them will find, according to his ability and the position which he occupies, means for favoring more or less the interest of the road.

Participation of employés in profits to a reasonable degree established in advance need not prevent payment for extraordinary services, and it would also be well to reserve as a provision for exceptionally bad years part of the percentage to be divided.

In applying the system of premiums in general according to the methods indicated above, it may happen without doubt that here or there an agent will gain an advantage which is not really due, but the point which can be doubted is that every individual interested will develop more zeal in his field of activity than if he did not expect payment. Concerning the exceptions, in aiming at a high standard, we cannot stop for too minute points of detail. Imperfection is common to all things in this world, especially when we are judging the actions of men. Even justice sometimes punishes the innocent. It can hardly be said that all employés without exception earn their wages, for there will always be some who look at appearances only and adroitly seem to work, but nevertheless do much less than their duty.

To seek an infallible system is to hunt for the impossible.

Concerning participation in increase of receipts or of profits, it would not be unjust to permit agents to share, provided they had done their duty under all circumstances, in the benefits produced by favorable conjunctures, or even by a fortunate chance, especially if, taking account of the chance of bad years, their salaries had been established at a minimum amount.

To apply the system of participation in the profits of an industrial enterprise is to interest employés in the results of bad as well as of good years, and to render them partners in the enterprise. It is to reconcile capital and labor and to hasten the solution of one of the most serious questions debated in our time; for if this struggle between capital and labor has existed in fact ever since society existed, it has never been as active or as important as now.

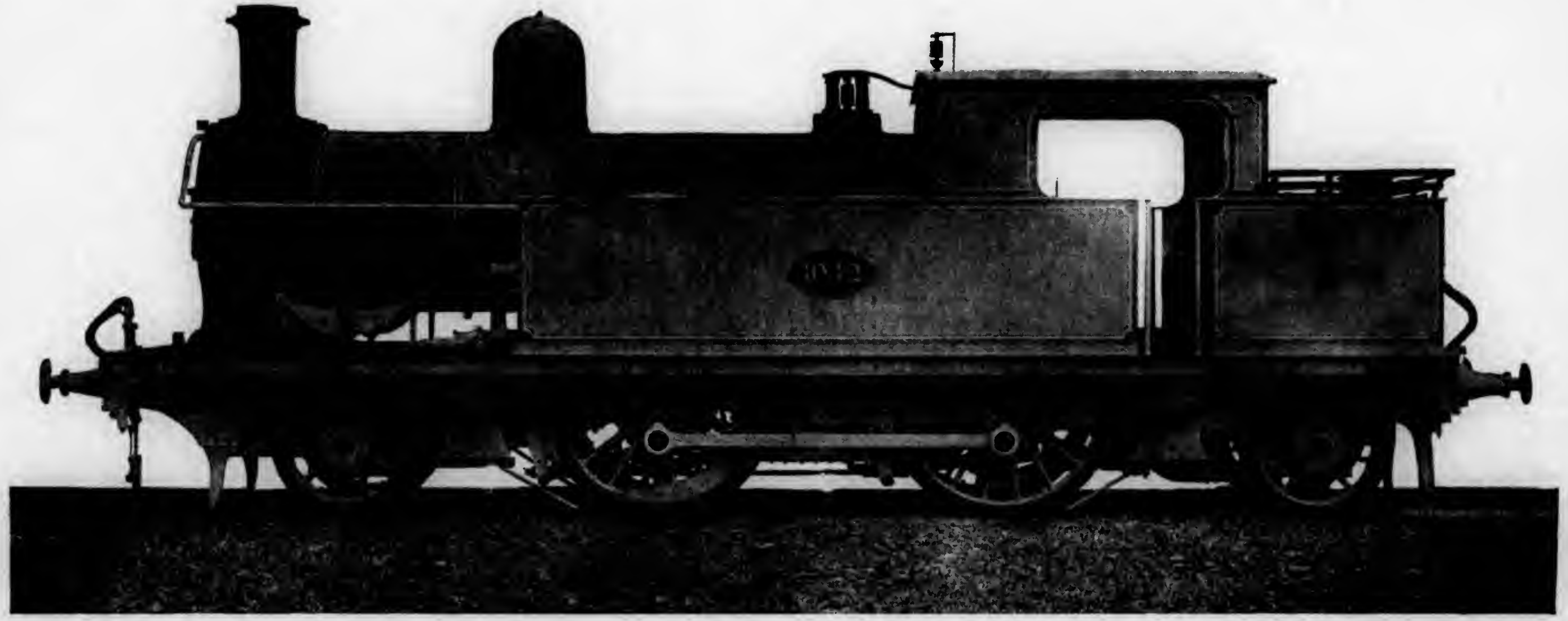
MORAL CONSIDERATIONS.

When we seek means for interesting employés in the prosperity of an enterprise by inspiring them with ideas corresponding with the modern conception of affairs, always ready to attribute a material motive to the action of men, we often forget other means leading to the same end. These not only cost nothing, but are really a clear gain to the prosperity of the enterprise. Although inspired by this same economic spirit which leads us to invent new methods, we should nevertheless cultivate and develop before all, the more because it is not done everywhere, the old principles to which we have alluded.

If money is much in life, it is not everything for a man. It is sometimes the case that a man will prefer a position, although less advantageous in a money point of view, to another more brilliant for reasons purely moral or sentimental. We see sometimes that the strict discipline indispensable in railroad service is confounded with want of consideration; energy with abuse of authority. We must not forget, whatever position we hold, that a good machine works without noise and does not wear itself out. The lubrication which oil furnishes to parts of a machine in contact is supplied the social organization by politeness and charity.

Self-esteem and esteem for superiors result from a good treatment, which is one of the most essential conditions to content employés and to identify them with the enterprise. To this should be added all proper means for cultivating ambition, *esprit de corps*, mutual consideration, etc.—in a word, everything which serves to render the service agreeable.

Thus, the methods of administration are not indifferent in this point of view. For instance, when we speak of a



"RADIAL" TANK LOCOMOTIVE FOR THE LANCASHIRE & YORKSHIRE RAILWAY, ENGLAND.

DESIGNED BY MR. JOHN A. F. ASPINALL, LOCOMOTIVE SUPERINTENDENT.

surplus of work to result from zeal in the service, it is necessary, before all, that the employé should have some leisure which would make him physically able to furnish this work, and it is necessary also that he should be in a somewhat cheerful or animated condition, which is, perhaps, still more indispensable for voluntary extra work than a material interest. Two things—of which it is difficult to say which is the cause and which is the effect—are injurious in this point of view to the interest of the railroad. They are *Bureaucracy* and *Centralism*.

Bureaucracy, where the form kills the thought, where the spirit is lost in the flow of words, not only costs time which could be much better employed in useful work, but makes the mind, by accustoming it to a barren activity, at last incapable of productive and practical work of any kind.

Excessive centralism, with a greedy desire to extend itself, on the one hand crushes the mind and limits it to superficial work, and on the other weakens it by suppressing originality and ambition in the employés scattered along the line.

Both of these, besides the expense caused by increased complication of the service, suppress the practical sense and the activity of agents, without which railroads cannot respond to what the public has a right to accept from them. Moreover, they cause employés envy, and deprive them of the possibility of sincerely interesting themselves in the prosperity of their companies. They are the more dangerous because, supported by some address, they are capable of showing results which may blind the eyes of those who do not look to the bottom of things, and only see the brilliant exterior. Everything goes well apparently; strict order reigns everywhere. The machinery works admirably; the financial result is surprising. One begins to believe in a magic power until the time when some sudden change shows, all at once, vices, defects, and mistakes which are found irreparable. This is also the principal reason why a system of premiums could be rejected when it is limited exclusively to the chiefs of branches of the service. The monopoly of material reward leads to a moral monopoly—that is to say, to bureaucracy and to centralism.

It is true that the great responsibility attending railroad service makes the observation of certain formalities indispensable, and even requires a certain degree of centralization. In consequence, a single head in the administration is necessary, but it is always desirable to restrain his action as much as possible. Always it is necessary to adopt as a maxim, "Write as little as possible," and to insist upon the principle of personal responsibility. Among those things which do not contribute to raise the feeling of honor, or to stimulate his ambition, we must always consider too strict control.

Among the means best adapted for exciting the zeal of agents and interesting them in the prosperity of the enterprise, we may consider the improved treatment of the employés, and especially those of the lower grades, which, from a point of view of expense, will compensate for the reduction in number by the use of mechanical processes; the employment of women; special rewards, for instance, for regularity in running trains; pensions for long service and provision for injuries; relief in case of sickness and similar matters, which there is not space to consider here, especially since some of these questions have been otherwise brought before the Congress.

From a point of view purely ethical—I had almost said æsthetic—one might almost be inclined to declare against any system of premiums, only admitting that all other methods, semi-material and semi-moral, except participation, have been tried. However, many reasons are in favor of the application of the principle of participation of profits, especially when they result from the decrease of expenses or the increase of receipts.

This is the delicate point of the question. The nature, the sentiments, the thought and the manners of a man cannot be regulated by a formula.

It is seen in fact sometimes that by a change of person in administration or in a branch of the service, the spirit of the direction and all the appearance of the service are modified. It is, therefore, in the interest of the service to counteract any personal influence which can eventually be unfavorable to the activity or to the zeal of the agents.

It would be very difficult to say which of the methods here treated should be preferred. That depends largely upon circumstances, and the system which might be applied with success upon one road would be a failure upon another. It would be better that each management, accepting the general principle, should join the elements indicated in the course of the discussion, and endeavor to form a complete and harmonious system, commencing in a comparatively narrow circle, determined by the special circumstances of the road, and enlarging it as opportunity offered.

This is the conclusion which I have reached after careful study. The method which, as I have said, may be best determined by local circumstances and by local conditions, is of less importance as long as no reasonable means are neglected for promoting the main object.

To make the employés zealous, they must have a direct interest in the prosperity of the railroad for which they work.

TANK LOCOMOTIVE FOR THE LANCASHIRE & YORKSHIRE RAILWAY.

THE accompanying illustration shows a tank locomotive for passenger service on the Lancashire & Yorkshire Railway, built at the shops of that company in Harwich, England, from the designs of Mr. John A. F. Aspinall, Locomotive Superintendent.

The general design is that of an engine with four coupled wheels, one pair under the boiler and one behind the firebox, and two pairs of bearing wheels, one under the front end of the engine, the other under the coal-box. The axles of these bearing wheels are provided with radial boxes, permitting the wheels to accommodate themselves to curves, and serving the same purpose as a truck.

Water is carried in the side tanks, as shown in the engraving, and coal in the box behind the cab, which is supported by an extension of the frames.

The boiler is 50 in. diameter of barrel and 10 ft. 7⅝ in. long; it has 220 tubes, 1¾ in. outside diameter. The firebox is 6 ft. long, 4 ft. 1 in. wide and 5 ft. 10 in. in depth. The grate area is 18.75 square feet, and the heating surface is: Fire-box, 107.68; tubes, 1,108.73; total, 1,216.41 square feet.

The cylinders are 18 in. in diameter and 26 in. stroke; they are placed inside, and the valves are worked by Joy's gear.

The driving wheels are 5 ft. 8 in. in diameter, and the bearing or radial wheels 3 ft. 7⅝ in. The total wheel-base is 24 ft. 4 in., divided as follows: Forward radial axle to coupled axle, 7 ft. 10½ in.; coupled axle to main driving axle, 8 ft. 7 in.; main driving axle to rear radial axle, 7 ft. 10½ in.

The weight of the engine in full running order is carried as follows: On forward radial axle, 30,240; on coupled axle, 39,200; on main driving axle, 31,920; on rear radial axle, 25,760; total, 127,120 lbs. The tanks will hold 1,340 gallons of water, and the fuel box two tons of coal.

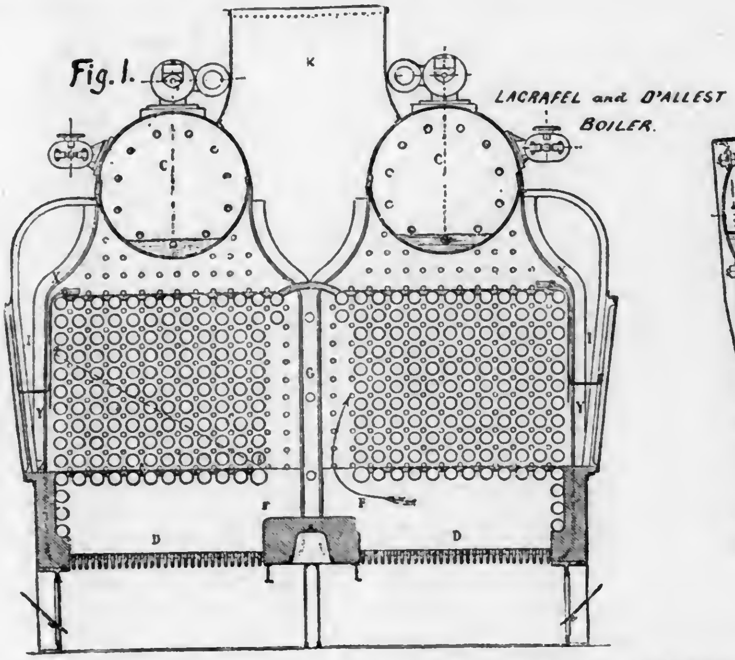
TUBULOUS BOILERS.

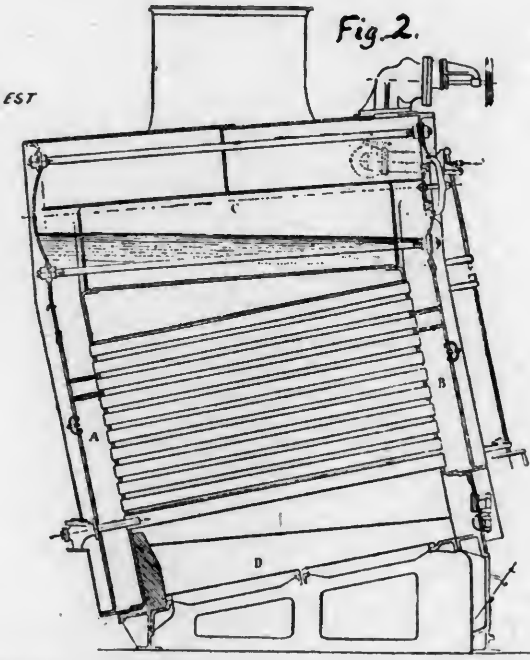
IN the articles on Tubulous Boilers, which were published in the JOURNAL for July last, page 319, and for August, page 346, several of these boilers were described and illustrated. These are supplemented below by descriptions of two more steam generators of this class, taken from the latest issue of the Bureau of Naval Intelligence.

THE LAGRAFEL & D'ALLEST BOILER.

This boiler is shown herewith, fig. 1 being a cross section and fig. 2 a longitudinal section. It consists of two plain flat-sided water-chambers, forming the front and back of the boiler, securely braced by numerous stay-bolts and the two connected by tubes. Above the tubes they are again connected by a cylindrical drum, in the lower part of which is the normal water-level, and the upper part

of which is the steam space. The whole is placed over the grates in an inclined position, the front being higher than the rear. The tubes are expanded against the tube-sheets, but not beaded over. Opposite each end of each tube there is a hole in the outer shell, sufficiently large to admit of the withdrawal and replacement of the tubes, closed by the ordinary plate and crow's-foot when the boiler is ready for use. At one side of the furnace the tubes are omitted, forming the combustion chamber. Over the lower row of tubes is placed a floor of fire-brick forming the crown of the furnace, and over the upper row a similar floor dividing the tube box from the space underneath the drum. The hot gases thus pass to one side of the furnace, up among the tubes, in a direction parallel to the front of the boiler, then up underneath the drum, in a reverse direction, to the smoke pipe. At the exit side of the tube-box a hanging baffle-plate prevents the escape of the gases at the top, and forces them to pass among the lower tubes.





THE LA GRAFEL & D'ALLEST BOILER.

The results obtained in a six-hour trial with this boiler are shown in the accompanying table:

Draft.	Pounds Coal per Sq. Ft. of Grate per Hour.	Pounds Water Evaporated per Pound of Coal.	Draft.	Pounds Coal per Sq. Ft. of Grate per Hour.	Pounds Water Evaporated per Pound of Coal.
Natural...	10.24	10.67	Forced....	30.72	8.82
"	15.16	9.58	"	40.96	8.89
"	15.36	9.23	"	51.20	8.43
"	15.57	9.04	....	.....	...
"	20.48	9.45	...	.....	....

In a double boiler, as shown in the sketch, the combustion chamber is common to both.

THE BARTLETT BOILER.

This boiler is shown herewith, fig. 3 being a half front view; fig. 4 a half cross section; fig. 5 an elevation, with the front end broken away to show the interior; fig. 6 a plan of the wing chambers; figs. 7 and 8 details of the tubes and brick lining.

The boiler consists of an upper chamber, U-shaped in section, from which are suspended by 4-in. water-tubes two other chambers, one on each side of the grate. Through these water-tubes pass 2-in. fire-tubes, connecting the spaces below the side chambers with the space above the upper chamber. In this upper space is also placed the steam-drum, connected on both sides with the upper ends of the U-shaped chamber by short horizontal 4-in. tubes, through which and the drum pass the 2-in. tie-rods holding together the legs of the U. As is customary with all boilers of this general type, there is a downcast pipe connecting the lower part of the drum to the side chambers. Just beneath the steam-drum, extending the entire length of the boiler from front to rear, is the feed-pipe, formed of two concentric pipes terminating in a spherical chamber outside the boiler shell. The feed-water enters through the inner pipe, and is heated to the temperature due to the pressure carried during its passage to the spherical chamber, where separation of the solid matter and extraction of the grease takes place. It then returns through the annular space between the two pipes to the front of the boiler, where it passes down an outside pipe, and enters the downcast pipes just above their junction with the side chambers.

The bottom of the upper chamber forms the crown of the furnace. The products of combustion pass among the tubes to the outer shell, thence down to the spaces below the side chambers, thence up through the fire-tubes to the uptake, in which the steam-drum is situated and around which the hot gases pass on their way to the smoke-pipe. The steam-drum is fitted with baffle-plates and a dry-pipe, and all flat surfaces are securely braced with socket or screw stay-bolts.

AERIAL NAVIGATION.

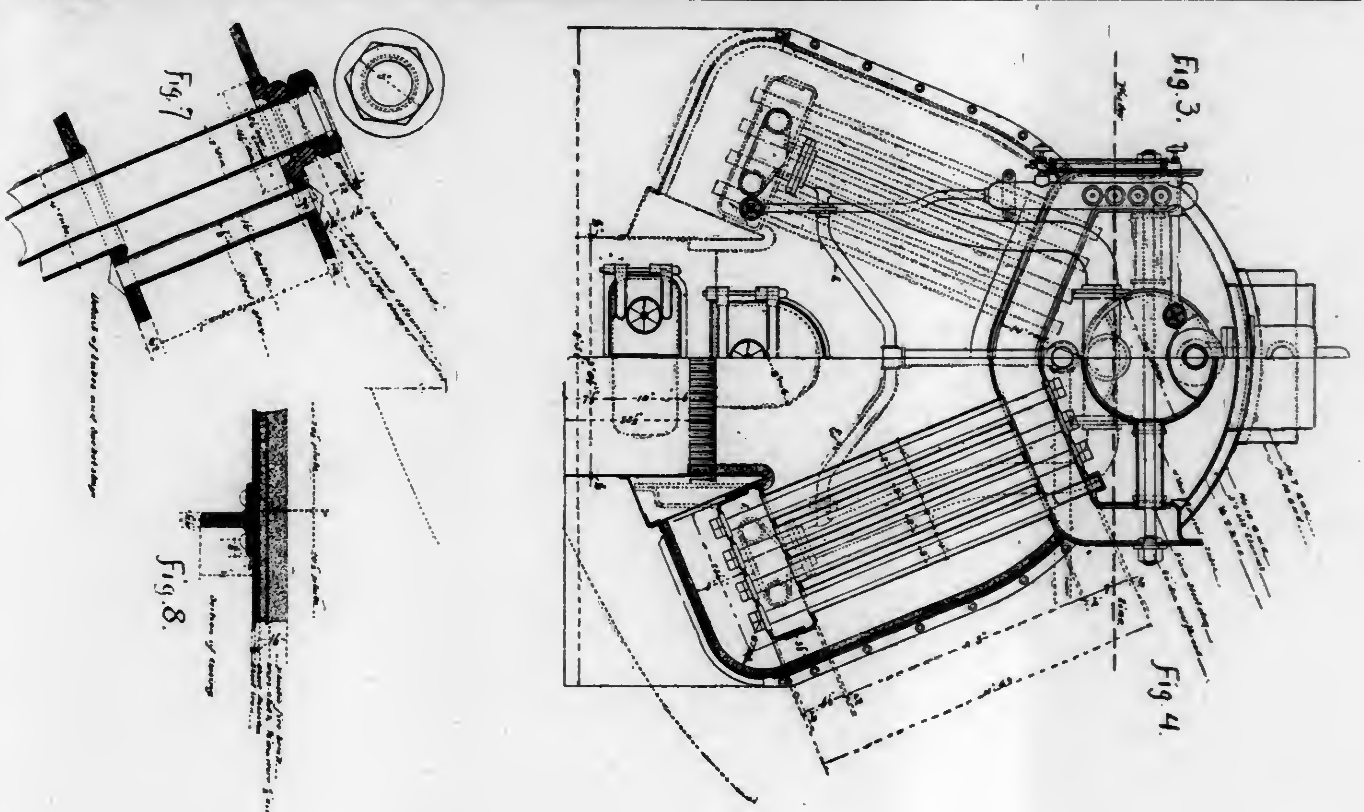
By O. Chanute, C.E., of Chicago.

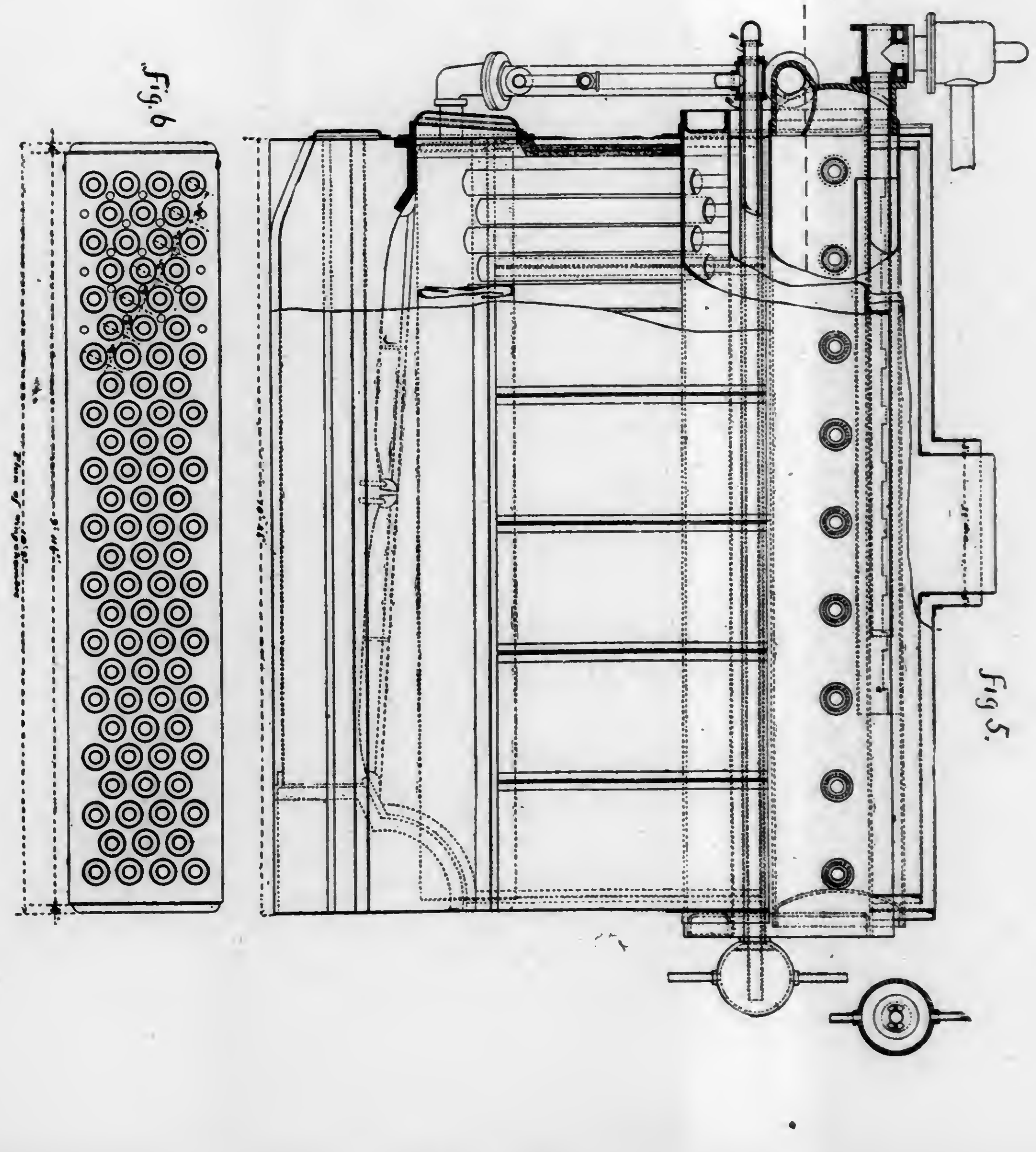
(A lecture to the students of Sibley College, Cornell University; delivered May 2, 1890.)

(*Concluded from page 444.*)

PART II.—AVIATION (*Continued*).

This brings up the question of possible motors, and if we confine ourselves for the present to 25 miles per hour, and assume the power required at 10 H P. per ton of apparatus, we see at once that only a fraction of that weight can be devoted to the motor. Let us assume, and I think this is not far wrong, that only one-quarter of the weight can be apportioned to the motor and its supplies; the remaining three-quarters being required for the weight of the framing, the aeroplane surfaces, the various appurtenances, and the aeronauts, we then have but $\frac{2000}{4 \times 10} =$





THE BARTLETT TUBULOUS BOILER.

50 lbs. per H.P. as the weight allowable for the motor and its supplies for such period of time as it is to consume in its trip. This does not greatly differ from the proportion in the pigeon, whose pectoral muscles weigh $\frac{10}{43}$ of his total weight, or $46\frac{1}{2}$ lbs. per H.P., including, it must be remembered, the stored-up energy which enables him to accomplish long flights without alighting.

Now, how does this compare with the weight of the engines manufactured by man? There are three classes of motors now in general use:

1. Steam-engines.
2. Gas-engines.
3. Electric motors.

The machines in common use, being designed chiefly for strength and durability, are needlessly heavy, and it is only by inquiring into what has been done for special purposes that we shall get an idea of their possibilities.

Thus as to steam-engines: Ordinary stationary machines weigh with their boilers from 500 to 1,600 lbs. per H.P.; locomotives, from 200 to 300 lbs.; marine engines for Atlantic steamers, 480 lbs., and light launch engines—those of Herreshoff, for instance—some 60 lbs. per H.P. For aeronautical purposes, however, a steam-engine was built by Stringfellow, which weighed but 13 lbs. and exerted 1 H.P., and another was built by Moy and Schill of 3 H.P. and 80 lbs. weight, thus being about 27 lbs. per H.P.

But these weights, while including the boiler, do not include the water and fuel. These supplies may be estimated at 22 lbs. of water and 4 lbs. of coal per hour, so that if a large engine can be built as light per H.P. (13 lbs.) as that of Stringfellow, it would still need, if for so short a trip as two hours, 52 lbs. of supplies per H.P., making a total of 65 lbs., including the engine itself.

The principal weight is that of the water. It has been proposed to utilize part of this over and over again, by equipping navigable balloons with surface air condensers, but the difficulties in the way of this, chiefly from the added weight, are almost insuperable.

Next, therefore, gas and petroleum engines suggest themselves. As now made they are excessively heavy, weighing from 280 to 1,000 lbs. or even more per H.P., so that the advantages of dispensing with the boiler and its water supply are completely lost. They are comparatively of recent invention, however, and it is believed that corresponding reductions of their weight can be made,* such as have been effected for the steam-engine, and as will be seen hereafter for electric motors, and that this is a promising field for experiment; for even if aerial navigation be an Utopia never to be realized, improvements which will permit a reduction in the weight of gas-engines are likely to cheapen their cost materially, and to extend their use, as well as the profits of their builders.

And, lastly, we will consider the electric motors, with which whatever of success the navigable balloon has so far attained has been accomplished. They involve, like the steam-engine, two separate parts, the motor proper and the generator, which latter may be either a primary battery or an accumulator.

The weights of the motors or ordinary dynamos used in this country run from 92 to 260 lbs. per H.P. developed, while abroad they run from 68 to 350 lbs. per H.P.; but the special dynamo used by Commandant Renard weighed but 26.4 lbs. per H.P., and a very small one, built of aluminium by M. G. Trouvé, weighed at the extraordinary rate of but 7.7 lbs. per H.P.

M. Trouvé is now building for the Portuguese Government a 10-H.P. dynamo, which will weigh less than 220 lbs., and which is to be used to drive a navigable balloon. The total weight of the motor, batteries for several hours of work, screw and accessories, is estimated at 1,496 lbs., or at the rate of 149.6 lbs. per H.P. developed.

Contrary to expectation, accumulators are found, by comparison of numerous data from various makers, gathered by M. Tissandier, to be actually heavier than primary batteries. As they are charged to last various periods of time, it is necessary, in order to compare them, to reduce them to the common standard of one H.P. for one hour, and it is then found that accumulators of the best make weigh from 107 to 162 lbs. per H.P. per hour, a fair average being 135 lbs.; while the primary battery of Commandant Renard is stated by himself to weigh but 66 lbs. per H.P. per hour, and to last a little over $1\frac{1}{2}$ hours, this being the present possible length of his trips. Thus the motor of the air-ship *La France* is seen to be decomposed into 26.4 lbs. of dynamo and 103.6 lbs. of primary battery, making in the aggregate the 130 lbs. per H.P., as has already been mentioned.

It will be observed that all these weights of motors are in excess of the 50 lbs. per H.P., which have already been assumed as the weight which can be afforded for aerial navigation, and yet not so greatly beyond it as to shut off all hope of improvement. Hitherto it has not been generally realized that the chief obstacle in the way of success is the want of a light motive power, one which shall develop great energy with little weight, and it is possible that when inventors turn their attention in this direction still lighter motors than at present known shall be the result.

It has been suggested repeatedly that a suitable motor for aerial navigation may be found by the invention of some kind of explosive engine, utilizing the force of gunpowder, nitro-glycerine or some other substance which can be flashed from the solid or liquid form to the gaseous condition; but such a motor is yet to be invented, and, what is more difficult, regulated and perfected. Attempts in this direction, notably with gunpowder, actually antedate the steam engine, but the difficulties of controlling power so intense and so rapidly generated have hitherto been found too great to be overcome. It would be rash to say that they cannot be, although true explosive engines have thus far exhibited an unpleasant irregularity of working, frequently giving deficient strokes, but at times coming out with powerful explosions which may kill the inventor.

It is believed that gas or petroleum engines, which are also explosive engines, with the difference that the working substance is already in the gaseous form, and thus subject to fewer irregularities of expansion, present greater chances of success in obtaining a light motor for aerial purposes, and would-be inventors are advised to turn their attention in this rather than in other directions.

But even if the motor is worked out, there will remain some serious difficulties to be encountered before man can fly through the air at satisfactory speeds. The first of these is the requirement for absolute stability which has already been alluded to. The apparatus must balance itself in the air automatically, and must possess sufficient surface to come down as a parachute should the machinery break down while sailing. The second difficulty will consist in the necessity for obtaining high initial velocities, so that the sustaining pressures shall be great, and that the dimensions and weight of the apparatus may consequently be reduced to a minimum. This difficulty of getting under way is the principal one encountered by birds, and probably furnishes the reason why none of them have attained the size of land and marine animals.

It has been pointed out that there are no flying birds much over 30 lbs. in weight, and, reasoning from analogy, it has been argued that man cannot hope to improve upon nature in this direction; but not only are birds much more complicated in structure than a flying machine needs to be, having many functions to perform (such as wing-folding, feeding, reproduction, etc.) besides that of mere flight, but they evidently expend much more energy in starting than in any other portion of their evolutions.

¶ The smaller ones jump from the ground into the air with all their might, and then beat their wings with much greater rapidity and amplitude than in their normal flight. If rising vertically they soon exhibit signs of distress. The larger birds in starting from the ground are compelled to run considerable distances, always against the wind, in order to gather headway and supporting power, and even with the most energetic flapping they cannot rise at a steeper angle than 45°. All birds prefer to start from a perch, for by directing their first course downward they gather velocity from the action of gravity; at times some

* Since reading this lecture, the Author has seen an account of a three-cylinder petroleum engine built for marine purposes, in France, which develops 5 H.P., and weighs but 440 lbs., thus being in the ratio of 88 lbs. per H.P. It consumes, as near as may be, 1 lb. of petroleum per H.P. per hour.

of the larger ones obtain relative velocity by simply spreading their wings wide open to the breeze while yet on the perch, the object in every case being to avoid the great exertion required to obtain speed, for once fairly under way they are masters of their movements.

Resort to some equivalent devices will evidently be open to flying machines, but it is evident that until the question of stability has been thoroughly worked out, such experiments will be exceedingly dangerous; no such apparatus has yet succeeded in raising itself from the ground with the whole of its motive power, and the most that can be said at present is that recent elucidations of the laws of flight seem to indicate that it is not impossible for man to succeed with an aeroplane.

There are probably scores of shapes which can be made available for such machines, just as there are hundreds of forms of birds who display various peculiarities in their flight; but in every case there will be the same requirements as to a light motor, absolute automatic stability and some device for gaining initial velocity, as well as for landing safely. This will require much experimenting, and a beginning has scarcely been made, so that even granting the accomplishment possible, the working out of the problem may prove to be slow.

Success might be much hastened, however, by a working association of searchers in this field of inquiry, for no one man is likely to be simultaneously an inventor, to imagine new shapes and new motors; a mechanical engineer, to design the arrangement of the apparatus; a mathematician, to calculate its strength and stresses; a practical mechanic, to construct the parts, and a syndicate of capitalists, to furnish the needed funds. It is probably because the working out of a complex invention requires so great a variety of talent, that progress in other fields has proved so slow, several generations sometimes passing before an important invention such as that of the steam-engine, the telegraph, or the reaping machine is finally perfected and brought into general use.

I have refrained in this paper from discussion of the various mathematical formulæ concerning air resistances, because not only are they a matter of controversy, which must hereafter be settled by experiment, but also because the figures of M. Drzeweiki, which are based on empirical formulæ, may be in need of revision; for the benefit of the curious in such matters, however, it may be stated that his papers can be obtained (in French), as they are in print.

CONCLUSION.

To sum up, therefore, the present "State of the Art"—if it has yet progressed sufficiently to be called an art—may be stated as follows:

A measurable success has been attained with navigable balloons. They have been driven 14 miles per hour, and it is probable that speeds of 25 to 30 miles an hour, or enough to go out when the wind blows less than a brisk gale, are even now in sight. Very much more speed than this is not likely to be obtained with balloons, for lack of sufficiently light motive power, and because of unmanageable sizes.

Much greater speeds can perhaps be attained eventually with aeroplanes; recent investigations indicate this; but even a beginning is prevented by the lack of a light motor, and by questions as to the stability of the apparatus as well as to safe ways of gaining high initial velocities. Whether these difficulties will ever be overcome no one knows, but they indicate the direction for investigation and experiment, while the probable benefits to man of a solution of the problem are so great that they are well worth striving for.

Success with aeroplanes, if it comes at all, is likely to be promoted by the navigable balloon. It now seems not improbable that the course of development will consist, first, in improvements of the balloon, so as to enable it to stem the winds most usually prevailing, and then in using it to obtain the initial velocities required to float aeroplanes. Once the stability of the latter is well demonstrated, perhaps the gas-bag can be dispensed with altogether, and self-starting, self-landing machines substituted, which shall sail faster than any balloon ever can.

If we are to judge of the future by the past, such improvements are likely to be won by successive stages, each fresh inventor adding something to what has been accomplished before; but still, when once a partial success is attained, it is likely to attract so much attention that it is not impossible that improvements will follow each other so rapidly that some of the present generation will yet see men safely traveling through and on the air at speeds of 50 or 60 miles per hour.

BRIEF NOTES ON INDIAN RAILROADS.

By George L. Cumine, C.E.

It must be understood that the present article does not pretend to give any detailed account of the railroads of India, but is simply a series of notes taken on a trip from Calcutta across India to Bombay.

The principal railroad of Bengal is the East Indian, which runs up the fertile basin of the Ganges, and at Allahabad, 565 miles, is only 300 ft. above sea-level. There it forks, extending southwestward about 230 miles to Jubbulpore—elevation, 1,300-1,400 ft.—and northwestward to Delhi, which is 800 ft. above the sea and 955 miles from Calcutta.

Through trains to Bombay run from Jubbulpore to their destination over the Northeast Extension—616 miles—of the Great Indian Peninsula, of which road the southeastern arm reaches from Bombay *via* Poona to Raichur, about 440 miles, on the way to Madras. Both arms attain, within 100 miles of Bombay, an altitude of nearly or quite 2,000 ft.

The Bombay & Baroda runs from Bombay about due north to Ahmedabad, 309 miles.

All these are broad-gauge (the first two mentioned with a large percentage of double track), laid with rails of the English pattern, carried in cast-iron chairs, either on timber cross-ties or cast-iron sleepers. In the latter case chair and sleeper are cast together, and the gauge is maintained by a light-looking wrought-iron tie. The ballast is rock. For new joints plates deeper than the ordinary strap seem to be in favor, and on the East Indian I noticed some plates with six bolts; but the joint question does not seem to have produced as many competing designs here as with you. All joints are suspended and opposite.

Keys are invariably outside the rails. On the Great Indian Peninsula I noticed cylinders of coiled steel ribbon substituted on some stretches for wooden keys. The 2.7 per cent. grade on the road is laid with timber ties and heavy four-hole chairs, like the English main lines.

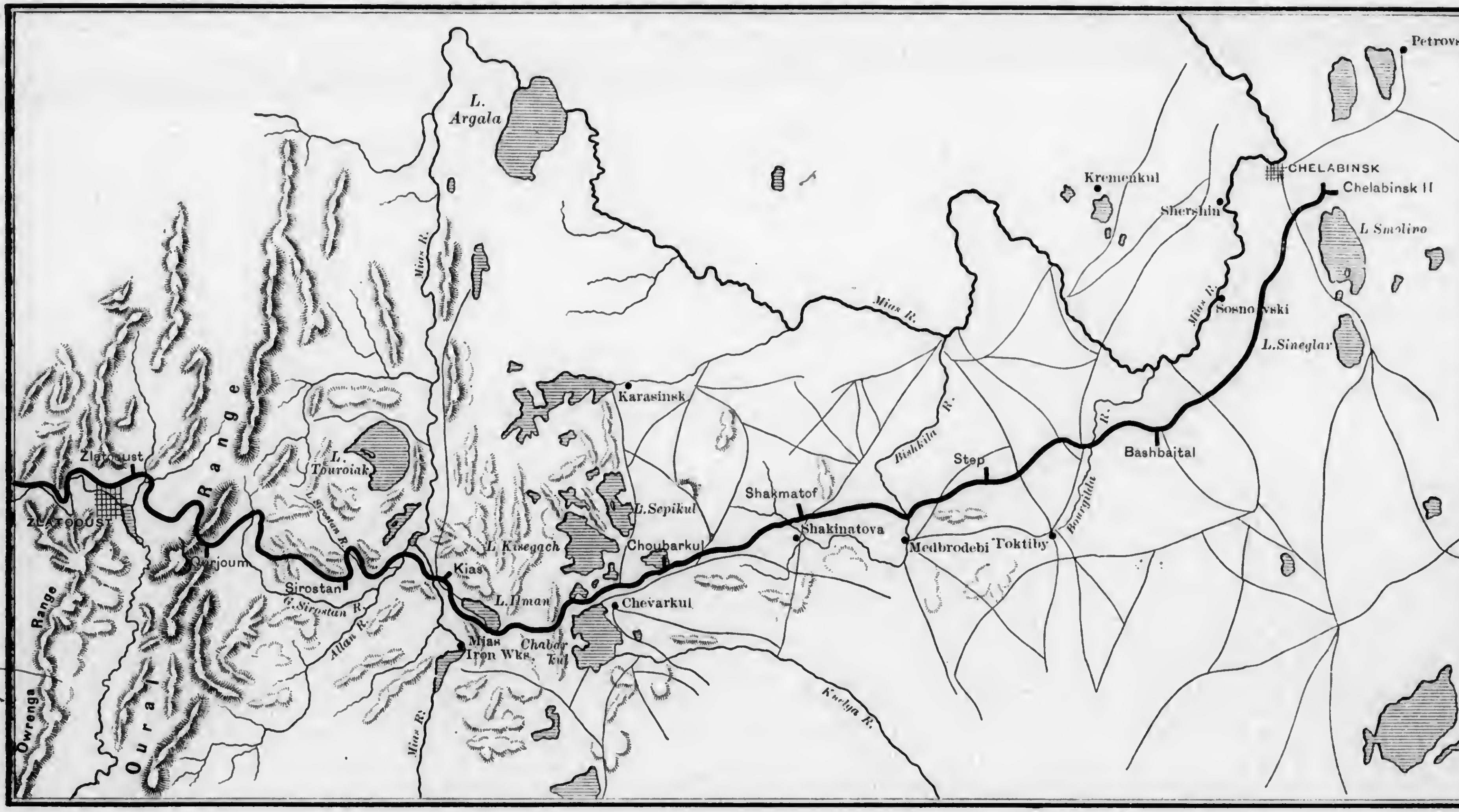
These tracks are generally excellent, though the joints pound a little in places.

I crossed the Ganges at Benares by the fine Dufferin Bridge, and traveled over the Oude & Rohilkund to Lucknow and Cawnpore. This is also a broad-gauge road, but with brick ballast under flat-footed rails, and the less said about that track as I found it the better; for considerable stretches every joint was a battle.

Very easy curves and, in Bengal, light grades prevail. Even on the Great Indian Peninsula 6° seems the maximum on the extremely heavy work attending the ascent of the Ghauts. On the Bombay & Baroda are freight and third-class passenger cars mounted on three axles, with some lateral traverse in the boxes. All the East Indian and Great Indian Peninsula cars seem to be four-wheeled. Metal under-frames and, for new freight stock, metal bodies are used.

First and second-class cars have lavatories; occasionally (first-class) bath-rooms and sleeping accommodation, the passengers finding their own pillows and covering. A coach contains two such compartments, each with its own toilet-room.

The lower berths are fixed, and on a long journey do not prove comfortable seats. Third and intermediate class cars are arranged with transverse seats, as in England. Lamps of the abominable pattern so well—or ill—known in Europe are universal here. At 40 miles an hour these four-wheelers sometimes knock about very unpleasantly, but that speed does not seem very often attained. All passenger stock has double roofing, carried down the sides



THE ZLATOOUST-CHELABINSK SECTION, SIBERIAN RAILROAD.

DISTANCE FROM ZLATOOUST TO CHELABINSK, 156.25 VERSTS = 103.5 MILES.

and ends a foot or more. Side buffers and ordinary English couplings are used on the broad gauge.

Motive power looks much as in England. Six-connected inside engines for freight, and for passengers eight-wheelers, four-coupled, with leading truck and—except on the East Indian—inside cylinders are generally used. On the Oude & Rohilkund I saw some eight-wheel engines with inside cylinders driving an intermediate shaft, on which were outside cranks bearing in the side-rods; these had been originally all-coupled, but the front lengths of the side-rods, right and left, had been taken down. Apparently these are not being imitated.

Continuous brakes are not much in evidence yet, though one sees the vacuum fittings on some engines.

Speeds are very low; for instance, the mail across India only averages about 23 miles per hour.

The Thull Ghaut, on the northeast arm of the Great Indian Peninsula, has a switchback at about 1,000 ft. elevation; up to it the maximum grade is 1.67 per cent.; from the switchback the remaining 900 or 1,000 ft. is attained on a 2.7 per cent. grade, whether equated or not I do not know. Over this trains of about 20 cars are worked by a pair of eight-connected tank engines and four "incline brake vans"; ascending there is an engine at front and rear, but descending both are in front.

I came from Delhi to Ahmedabad over the Rajputana-Malwa State narrow-gauge road, which with the broad-gauge Bombay & Baroda forms the Bombay, Baroda & Central India. The track, of flat-footed rails spiked to timber ties in rock ballast, was excellent. Although attaining considerable altitude, I saw no grades exceeding 40 ft. per mile and no sharp curves. The stock is generally four-wheeled, but double-truck and six-wheel flexible-base freight cars are also in use. The engines look big for the gauge, and have generally outside frames, often with inside cylinders. The road has iron and masonry bridges, and flat, occasionally stone-pitched, slopes. Metal and stone fence posts, signal posts and telegraph poles are characteristics of the various roads I have mentioned. These, combined as they are with good ballast and careful drainage, must keep the cost of maintenance and renewals low.

Passenger fares are wonderfully low in India, ranging, apparently, from 9, 8 or 7 rupees for first class to $1\frac{1}{3}$ to 1 rupees for third-class per 100 miles; the second-class fares are half the first, and many Europeans travel second. Value of the rupee is anything between 33 cents and 45 cents American currency.

Freight rates are also fairly low, apparently; for long hauls of coarse freight on the East Indian about $\frac{1}{3}$ anna per ton-mile. Sixteen annas go to the rupee.

Passengers appear to afford about one-third of the gross receipts on the Great Indian Peninsula and quite one-half on the East Indian; the proportion of first and second class being very small indeed.

The Government loses on the railways only on account of the depreciated rupee.

Interest on the borrowed capital being guaranteed at about $4\frac{3}{4}$ per cent., the actual payments amount to about 7 per cent. Indian currency, and this the railroads fail to produce by 2 per cent.

Old rails are put to many uses here, as, for instance, telegraph and fence posts, roof trusses, floor beams in buildings and open culverts, etc.

One notices a marked absence of guard-rails on the smaller structures. Probably derailments are comparatively infrequent, owing to the excellent track and low speeds.

Baggage registration is universal. The free allowance to first-class passengers is 100 lbs., and decreases about as the fares for the other classes.

As to other Eastern countries, I may say that there is a little railroad work doing now in the Malay Peninsula, but information is not easily obtained. The Dutch continue to take rails in Deli (Sumatra), principally, I think, for plantation roads.

Robert Gordon is still in Siam in the Government service, also a Mr. Bethje from, I believe, Krupp's establishment. I am afraid there will be no orders of moment for either Krupp or any one else for some years from Siam. According to later advices, Mr. Gordon has left Siam.

THE BEGINNING OF THE GREAT SIBERIAN RAILROAD.*

BY A. ZDZIARSKI, ENGINEER.

THE Oufa-Zlatooust Railroad, described in the previous article, was opened in September last; but it was some time before decided to begin the construction of its extension, the Zlatooust-Chelabinsk Railroad. The survey and location of this line was made in 1888; and work on the first 40 miles was begun last summer.

According to the survey the length of this line is 156.25 versts, or 103.5 miles. Starting from Zlatooust the line first rises along the western slope of the Oural Range for 10 miles; then reaching and passing the summit descends the eastern slope of the range along the valleys of the Little and the Great Sirostan, crossing both those rivers many times; then crosses the divide between the Great Sirostan and the Mias River. Crossing the Mias the line continues to descend the eastern slope of the Oural, passing near Lake Ilmen, then between Lakes Kisegach and Chonbarkul into a fairly level steppe or prairie region. Crossing the Bishkila and the Birgilda—both tributaries of the Mias—it finally reaches the district town of Chelabinsk, situated on the Mias, a tributary of the Irtish, which is in its turn a tributary of the Obi.

From this it will be seen that at Chelabinsk the road is fairly across the Oural and in the Great Siberian plateau.

Of the $103\frac{1}{2}$ miles of the road, about one-half was located in a difficult mountain country; the other half is over a level country, where the location was comparatively easy.

The estimated cost of the road is 7,954,378 roubles, or 76,854 roubles per mile. As before explained, it is difficult to express this in American currency, but an approximation would be $37,500 per mile.

The general designs for road and equipment are the same as for the Oufa-Zlatooust Railroad. The grade and bridges are for a single track, and sufficient sidings are provided to permit the running of nine trains daily in each direction. The water supply is sufficient for 12 trains daily each way; but at first the equipment of motive power and rolling stock will be sufficient only for one mixed train and one freight train in each direction daily.

The earthwork on the line is not easy, the average quantity being 67,000 cub. yards per mile; about half of all the excavation is in rock, more or less hard.

The water crossings are all masonry arch culverts or iron bridges. The culverts are 68 in number and vary in span from $3\frac{1}{2}$ ft. to 21 ft. The bridges all have iron superstructure on masonry abutments, and are 97 in number, as follows: 66 of 7 ft. span; 27 of spans from 14 to 56 ft.; 2 of 70 ft.; 1 of 105 ft.; 1 of 210 ft. span. The total weight of iron in the bridges is about 1,000 tons.

The rails are of steel, $65\frac{1}{2}$ lbs., of Russian manufacture, and the pattern of rails, the ballast, etc., are the same as on the Oufa-Zlatoousl road.

The buildings also are of the same pattern as on that road, wood on stone foundations. The smaller ones include 58 watchmen's houses and 25 section-houses; 15 of the latter are at stations and 10 at points between stations. There are 76 road crossings, each protected by a gate and watchman.

The station buildings are eight in number, one being of the second class, one of the third, three of the fourth, and three of the fifth class. The three engine-houses have nine stalls in all. For the water supply of eight stations there are required seven pumping engines, which vary from 4 to 10 H.P.

There is at the terminus a large turn-table of the Sellers pattern, and a weighing bridge. The station equipment requires 75 switches; 16 green signal disks; 16 semaphores, of wood; 35 stop-blocks and 25 switch-houses.

The motive power at first consists of 10 locomotives of the standard eight-wheel or freight pattern. These weigh 42 tons, empty. Cars will be supplied from the connecting line.

* See previous articles on the Great Siberian Railroad in the JOURNAL for June, 1890, page 258, and for September, 1890, page 397. The location of Chelabinsk, etc., will be seen on the map of Siberia on page 259, June number.

As to the estimated cost, it will not be without interest to give a detailed statement of the distribution to the different works on the road; and such a statement will be found in the accompanying table.

No.	Description of Work.	Cost in Roubles. Total.	Per mile.	Per cent. of Total.
1	Expropriation of lands, etc.	105,600	1,020	1.3
2	Earthwork	2,463,732	23,804	31.0
3	Bridges	1,675,230	16,186	21.1
4	Track	1,701,482	16,440	21.4
5	Road accessories	22,066	213	0.3
6	Telegraph line	39,857	385	0.5
7	Road buildings and gates	143 550	1,387	1.8
8	Station buildings	401,150	3,876	5.0
9	Water supply	129 710	1,253	1.6
10	Station accessories	117,950	1,140	1.5
11	Rolling stock	349,650	3,378	4.4
12	General expenses	583,256	5,635	7.3
13	Extraordinary expenses	78,145	755	1.0
14	Controlling and police	61,000	590	0.8
15	Sundries	82,000	792	1.0
	Total	7,954,378	76,854	100.0

The item of track is made up as follows: Rails, 953,520; fastenings, 176,889; ties, ballast and tracklaying, 571,073; total, 1,701,482 roubles, as in the table.

CONTINUATION OF THE ROAD.

The first section of the Great Siberian Railroad, as just described, ends at Chelabinsk, a district town situated just beyond the geographical boundary between Europe and Asia—the Oural Mountains—but still within the administrative or political boundaries of European Russia.

From Chelabinsk the railroad may be continued to Ekaterinburg, a distance of 133 miles. That town is a main point on the Oural Railroad, which extends from Perm on the Kama River to Tumen on the Toura, and thus connects the watershed of the Volga—to which the Kama is a tributary—with that of the Irtish and the Obi. As the Oural Railroad has its eastern terminus at Tumen, there is, in summer, a connection with the important town of Tomsk by boats on the Toura, Irtish and Obi rivers.

On the other hand, should the opinion of M. Mejeninov, as to the necessity of a continuous railroad line, prevail, Chelabinsk will be the starting point for the Central Siberian Railroad.

The location of such a line from Chelabinsk to the Tom River will not be difficult, the country being generally level. From Chelabinsk it would go eastward to Kourhan and there cross the Tobol River; then through Petropavlovsk on the Ishim to Omsk, where it would cross the Irtish. From this point it would follow up the right bank of the Om River to Kaïnsk, then take the line of the post road to Kolivan and, crossing the Obi between Kolivan and Doubovinska, ascend the divide between the Obi and the Tom, crossing the latter about 50 miles from Tomsk; that town could best be connected with the main line by a branch. From the crossing of the Tom the road would go directly to Mariinsk, which is a point on the line already located for the Central Siberian Railroad, starting from Tomsk.

In the mean time, however, the railroads have been located to connect the various sections already provided with water communication. These locations must form the subject of another article.

UNITED STATES NAVAL PROGRESS.

One of the questions which will soon have to be discussed and settled in connection with the new Navy is that of sheathing steel ships. So far, none of the new vessels have been sheathed, and the rapid fouling of bottoms has seriously affected the speed of the new cruisers. Neither the *Charleston*, on her recent trip to Honolulu, nor the *Baltimore*, on her voyage to Stockholm, showed the speed expected of them, and the condition of their bottoms was undoubtedly the cause. The expense of docking and cleaning a large ship is considerable, but under present conditions and regulations this process will have to be gone through twice every year.

The question has been much discussed in England, also, and ships have been built there in both ways, but it cannot be said that any fixed rule has been adopted. This matter was ably discussed by Naval Constructor Hichborne in a paper read before the Naval Institute last year.

CONTRACTS FOR NEW SHIPS.

The bids received at the Navy Department for the three new battle-ships and for Cruiser No. 12 were opened October 1, according to previous notice.

For the battle-ships four bids were received, as follows:

1. The William Cramp & Sons Ship & Engine Building Company, Philadelphia, offered to build one battle-ship on the Department plans for $2,990,000, or two for $2,890,000 each; one battle-ship on their own plans for $3,120,000, or two for $3,020,000 each. As to their own plans, the following statements were made in the bid:

The Navy Department's scheme, plans and specifications for hull and machinery are adopted. We propose to add 12 ft. to the length of the vessel, increasing the displacement, when at the same normal draft of 24 ft., by 480 tons, utilized as follows: Additional length of the hull and armor about 197 tons, the balance, 283 tons, to be utilized at the Department's discretion in supplying additional side-armor plating 3 in. in thickness, forward and abaft, extending the present 18-in. armor-belt from the berth deck to just above the protective deck, and in providing an additional thickness to the armor around the guns. The construction of hull and machinery, arrangements of decks, quarters, fittings, etc., disposition of battery, types and dimensions of boilers, etc., will be upon the Department's plans and specifications.

The advantages of these additions to the Department's design are as follows:

First. Much better protection to the underwater ends, as the 3-in. armor on the ⅝-in. plating now there will be sufficient to break up high explosives, and in conjunction with the belts of cellulose now along the slopes of the protective deck will prevent the entrance of water to these places.

Second. Greater proportionate length of armor-belt, leading to a large protected water-line area, reducing the sinking when the ends are riddled or blown away by heavy shells, and so preserving a greater height of armored free board.

Third. Greater stability with riddled ends.

Fourth. Greater coal capacity.

Fifth. Even with the 3-in. armored belt, above referred to there will be a number of tons of surplus buoyancy which can be utilized in increasing the thickness of the protection to the 6-in. and 8-in. guns.

Sixth. The 3-in. plating will greatly strengthen the ram-bow, and afford increasing protection to the steering gears.

Seventh. The greater length will add to the power of keeping up speed against head seas.

2. The Bath Iron Works, Bath, Me., bid for one battle-ship on the Department plans at $3,149,000.

3. The Union Iron Works, San Francisco, offered to build one battle-ship for $3,240,000, or two for $3,200,000 each.

4. The Risdon Iron & Locomotive Works, San Francisco, offered to build one battle-ship for $3,275,000.

For Cruiser No. 12—the three-screw protected cruiser of 7,300 tons—two bids were received, as follows:

1. The William Cramp & Sons Ship & Engine Building Company, on the Department plans, $2,725,000.

2. The Union Iron Works, San Francisco, also on the Department plans, $3,025,000.

The plans for the battle-ships were described and illustrated in the Journal for September, page 392; those for Cruiser No. 12 in the Journal for October, page 446.

The contract for Cruiser No. 12 was awarded to the Cramp Company at their bid of $2,725,000.

For the battle-ships the Department decided to adopt the alterations proposed by the Cramps, lengthening the ships 16 ft. and increasing their displacement about 700 tons. On this basis the contract for two of them was awarded to the Cramp Company at $3,066,666 each, and that for the third one to the Union Iron Works at $3,226,667, the price being adjusted to meet the additional size.

The additional displacement given these ships will be utilized by putting on some additional armor protection.

Bids have been asked for three more new vessels, the

Ammen harbor-defense ram, the torpedo gun-boat of 750 tons displacement, and a first-class torpedo-boat. For the torpedo-boat builders will be asked to put in their own plans; she is to be somewhat larger than the *Cushing*, and will be required to reach a speed of 27 knots an hour for a short distance.

THE TORPEDO-BOAT "CUSHING."

THE following very complete and interesting description of the engines of the *Cushing* is from a paper read by Passed-Assistant Engineer Stacy Potts, U. S. N., before the American Society of Naval Engineers, and published in the *Journal* of that Society:

The hull and machinery of the *Cushing*, with the exception of the boiler, were designed by Mr. Nathaniel Herreshoff, and built by the Herreshoff Manufacturing Company, of Bristol, R. I., under the inspection of Commander George A. Converse, U. S. N. The principal dimensions of the hull are as follows: Length over all, 137.5 ft.; extreme beam, 15.05 ft.; draft, 5.2 ft.; displacement, 105 tons. She has a ram bow, overhanging stern, twin screws, and a partially balanced rudder.

The main engines consist of two sets of quadruple-expansion engines of the vertical, overhead-cylinder type, the low-pressure area being divided into two, thus making five cylinders of 11½ in., 16 in., 22½ in., 22½ in., and 22½ in. in diameter, respectively, by 15 in. stroke of piston. They are connected by the usual rods to five cranks, which follow each other at an angle of 144°. This gives a very equal distribution of pressure, which shows itself in the very smooth manner in which the engines run and the almost total absence of vibration.

It is worthy of remark here that no water pipes are fitted for cooling off bearings, nor (with one exception) was a drop of water used on any of them in the trial trips, the exception being on one occasion when dirt got into a bearing on one of the eccentric shafts situated beneath an open hatch, which was kept from excessive heating by laying cotton waste soaked in water upon it. Each cylinder has its own valve chest inboard, each provided with a double piston valve. The main pistons and valves are packed by small cast-iron rings, and not a drop of oil is used or can be placed in either the cylinders or chests, a practice always adhered to by the builders, and which works well. The frames are of steel rods 1½ in. in diameter, braced diagonally, and form the cap bolts of the main bearings, which in turn are secured to a bed-plate consisting of a single sheet of wrought steel ⅝ in. thick, with openings cut through it for the passage of the cranks. This bed-plate is secured along its edges in a fore-and-aft direction to keelsons, also beneath the main bearings of the high-pressure and the after low-pressure cylinders, the intervening bearings having no support at all beneath, and during the highest speeds no signs of working or weakness were noticeable around this apparently weak part.

The valves are worked by cranks on a small shaft running parallel with the main shaft, and geared to it at the forward end by cut steel gear wheels; the reversing being done by partially rotating this countershaft by hand by means of a lever and spiral feathers and sleeves situated in the forward bearing. The reversing is done easily, and is practically instantaneous.

The cross-heads are of phosphor-bronze; this does away with all gibs, set-screws, keys, etc.; they envelope a couple of bar slides, the ahead bar being cast hollow and filled with water before or during a run and the water allowed to evaporate through the top. All of the oil cups are kept filled with horse hair to prevent the oil from jumping out, and are fed through pipes leading to a main tank on each engine. The main engines do nothing but turn the screws, all of the pumps being independent.

There is one surface condenser containing 1,052 sq. ft. of cooling surface; it lies low on the keel in the after end of the engine room, the tubes running fore-and-aft. The heads are conical and continue down through the bottom of the vessel about 8 in., forming a scoop for the circulating water to enter and discharge when the vessel is under way, the cooling water passing through the tubes once. The forward scoop is provided with a strainer, the after one is without, the idea being that any foreign substance that may enter the after scoop when backing would be washed out when going ahead again. Situated in the forward head are vanes 13⅝ in. in diameter, forming a centrifugal pump and driven by a single vertical engine 4 in. diameter by 4 in. stroke. This engine and pump are used when the vessel has no motion through the water. When running at a speed of about 20 knots, and steam is shut off the circulating engine, the engine and pump make about 100 revolutions per minute, by the motion of the scooped water passing through it.

There are three single-acting, vertical, single-trunk, bucket air pumps for each main engine; they are 10 in. in diameter by 5 in. stroke, and are placed alongside and above the condenser; they have no foot valves, the bucket and delivery valves being flat annular rings of composition ¼ in. thick. The pumps are worked from a cast-steel shaft, the cranks being 120° apart. On the same shaft are three vertical, single-acting plunger feed-pumps 2⅞ in. in diameter and 5 in. stroke. Each set of air and feed pumps is driven by two simple vertical engines 3½ in. in diameter and 5 in. stroke, and geared down 3.2 : 1. These engines are controlled by a small ball-governor, and work very well, the air and feed pumps making about 240 strokes per minute when running at maximum speed.

All of the auxiliary engines exhaust into the main condenser when not under way, and when under way into the low-pressure receivers; this increases the pressure there about 1 lb.

There are two boilers, one forward and the other abaft the engine compartment. They were built of domestic material by the Herreshoff Manufacturing Company, from drawings furnished by Messrs. Thornycroft & Company, England, and of the type used by that firm and well known. They each contain 38.3 sq. ft. of grate and 2,375 sq. ft. of heating surface, or a ratio of 1 : 60. They each weigh, empty, 9 tons, or 11 tons with water to the steaming level. The safety valves are set at 250 lbs., and the boilers have been tested to 500 lbs. per square inch.

THE DEVELOPMENT OF ARMOR.

By FIRST LIEUTENANT JOSEPH M. CALIFF, THIRD U. S. ARTILLERY.

(*Concluded from page* 460.)

XXI.—LAND DEFENSE—ENGLAND.

WHILE the Continental powers have, almost without exception, adopted cast-iron, steel or steel-faced armor for land fortification, England, beginning at a date when wrought iron was the only metal employed for armor plates, has up to the present time continued to use it exclusively upon her iron-clad forts. The possibility that masonry might have to give place to metal in the construction of fortifications had already been recognized before the outbreak of the American war, as shown by the experiments with metal shields, already referred to. But it required the actual demonstration of the power of rifled guns against brick and granite to make the necessity for such employment apparent.

England began the construction of iron-clad fortifications in the early sixties, and has at the present time works of this description at all important points upon the home coast and in the Mediterranean. In the English construction there are three different methods of applying armor for land defense: (1) casemate shields built into the masonry, (2) iron batteries, and (3) turrets. In the first case, which may be applied simply for the protection of the guns or upon the exposed side of a work, the armor, in three or more plates of from 5 to 10 in. in thickness, is built into the masonry, with the intervals between the plates filled in with wood or concrete. A strong iron frame is first built in and bolted to the masonry, and to this the

rear plate is secured; then each additional plate is bolted to the one next behind it. At Gibraltar, Malta and Portsmouth, where a wide arc of fire is desired, the batteries are circular in plan, and the guns, arranged on turn-tables, can fire from either one of two embrasures.

In the second class the entire walls are armored with plates of varying thickness, as in the former case, with concrete between the plates, except at the gun-ports, where wood is used. Fig. 1 gives in section a work of this kind. An important feature in the English system is the provision for increasing the thickness of armor upon an already finished work at any particular point, or for the removal of plates from one part of the structure to another. To the end that additional plates may be added, the outside plate is prepared therefor by the drilling of the necessary holes and the insertion of temporary bolts. At important sea-coast forts, as at Spithead and Plymouth, the works are planned and prepared for the subsequent addition of turrets upon their roofs. The Spithead forts can each carry five turrets above their iron-clad batteries.

Of the third class—revolving turrets—but one has as yet been constructed, and this at the end of the Admiralty Pier, Dover; this is shown in fig. 2. The wall has a thickness of 25 in., made up of three 7-in. and two 2-in. intermediate plates. The turret turns about a central steel pivot, upon a live ring of steel rollers, and is worked by steam power. It mounts two 80-ton muzzle-loading Armstrong guns, which are loaded from under the glacis by running them back and dropping the muzzles. Provision is made for the addition of extra thickness of metal, as in the case just mentioned.

The English works were constructed upon the now generally abandoned theory that a plate upon plate structure offers greater resistance to penetration than one that is solid. General Inglis, under whose supervision many of the English fortifications were constructed, holds, or then held, to the opinion that where the layers of metal are separated by narrow spaces filled with wood, cement, ordinary or, better still, iron concrete, there is greater resistance offered, more elasticity, and far less liability to crack than when the plate is homogeneous, provided that the intervals between the plates be so restricted that the head of a projectile will not have cleared the bulged or torn metal of the first plate before it encounters the face of the one next succeeding. An interval between plates of 5 in. was that generally adopted in the construction of the English forts.

XXII.—LAND DEFENSE—THE UNITED STATES.

Plans for the use of armor-plate for land defense have as yet taken no definite shape in the United States. The first step looking to the rehabilitation of our sea-coast fortifications was taken in 1885, when, under the Act of Congress of March 3 of that year a Board on Fortifications of nine persons, with the Secretary of War as President, two civilian members and six Army and Navy officers, was appointed to report as to "what forts, fortifications or other defenses are most urgently required, the character and kind of defense best adapted for each, with reference to armament," etc.

The report of this Board was of a character well calculated to startle the average frugal-minded, easy-going citizen, whose reading had not kept pace with the enormous strides taken in the growth of modern guns and armor-clad ships, and who had not awakened to the fact of how utterly worthless were the costly piles of brick and granite standing guard upon our coasts. The estimate submitted called for an expenditure of something over $126,000,000 for forts, their armament, and auxiliary defense of submarine mines, etc. Over $100,000,000 of this expenditure was reported as urgent, while $20,300,000 was for armor-plate

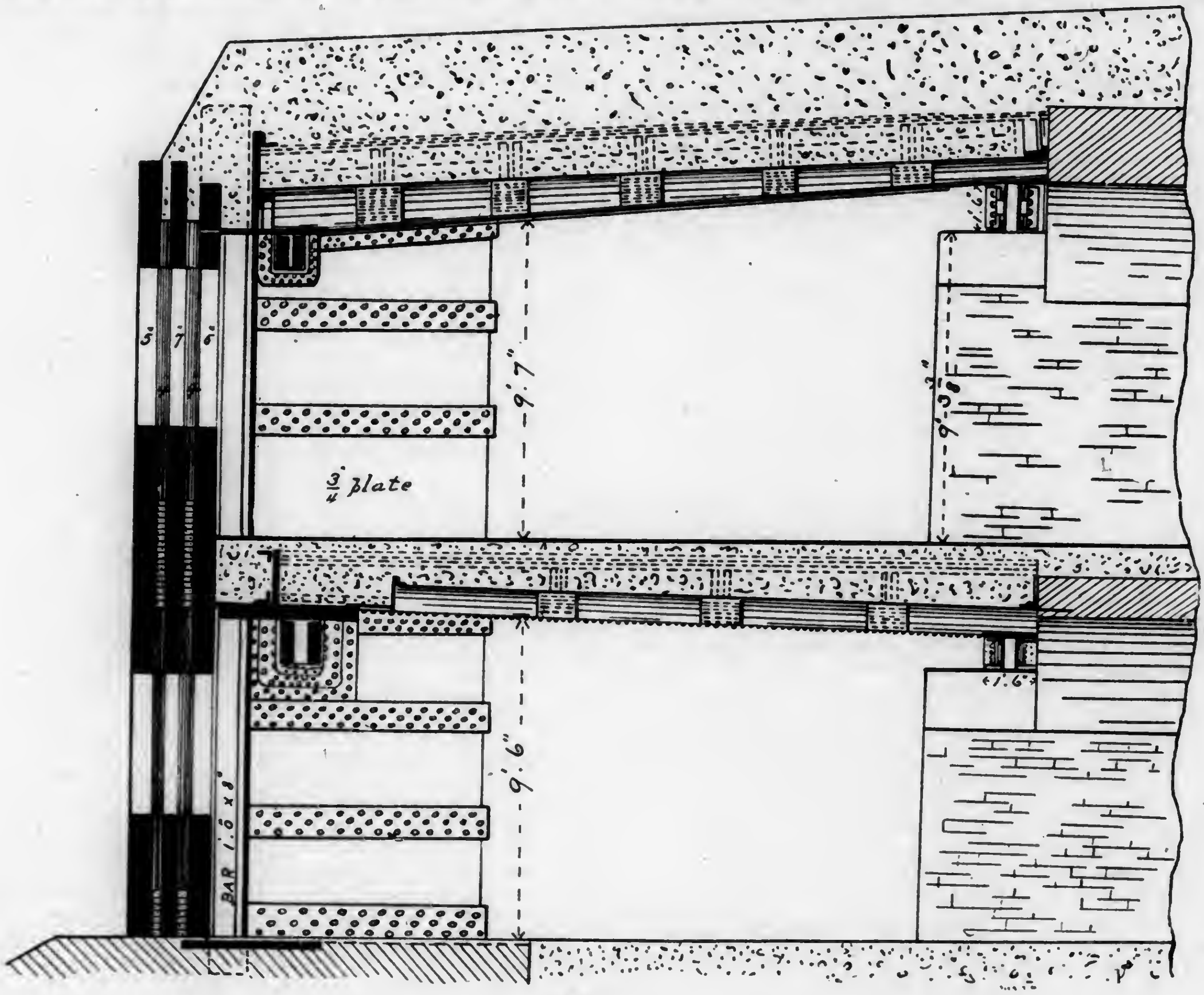


Fig. 1.

alone. The defenses of New York City call for nearly $8,000,000.

The Board recommended that the shore batteries should consist of fixed or revolving turrets, armored casemates and emplacements in barbette, the latter without armor, but with their guns generally mounted upon lifts or disappearing carriages. For New York nine 2-gun turrets were recommended, with 30 guns in armored casemates.

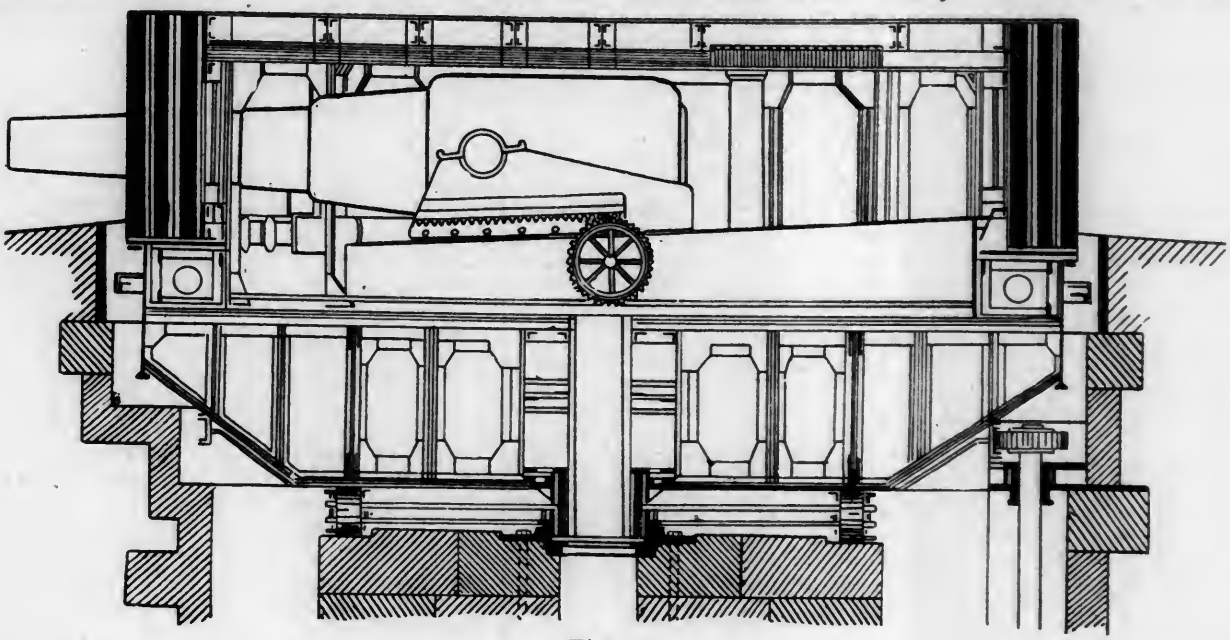


Fig. 2.

The act of September 22, 1888, created a Board of Ordnance and Fortification, under whose supervision will come the selection of plans for the construction of forts and batteries, the details of which will be worked out by the engineers. This Board has the matter now under consideration, but, so far as known, nothing has as yet been decided upon beyond the allotment, under the recent appropriation for fortifications, of about a million and a quarter for gun and mortar batteries, of which $726,000 goes to New York, $260,000 to San Francisco, and $235,000 to Boston. No other ports have been provided for. The remainder of the seven and a quarter millions appropriated goes for the purchase of land, of guns, mortars, torpedoes, etc.

The great advance that has been made in the direction of range, accuracy and rapidity of fire of what are known as the secondary batteries of war ships will, it is believed, compel an abandonment of the scheme for open barbette batteries, and necessitate a resort to armored structures in all cases where the fire of this class of ordnance is likely to be encountered, to say nothing of the inability of earth, except in the heaviest masses, to stop the projectiles of the modern high-power rifle. The calculated penetration of the 40-cm. Krupp gun at 1,000 yards is given at 82.5 ft. in heavy clay and 49 ft. in sand mixed with gravel ; that of the 6-in rifle about one-third these figures.

Fig. 3.

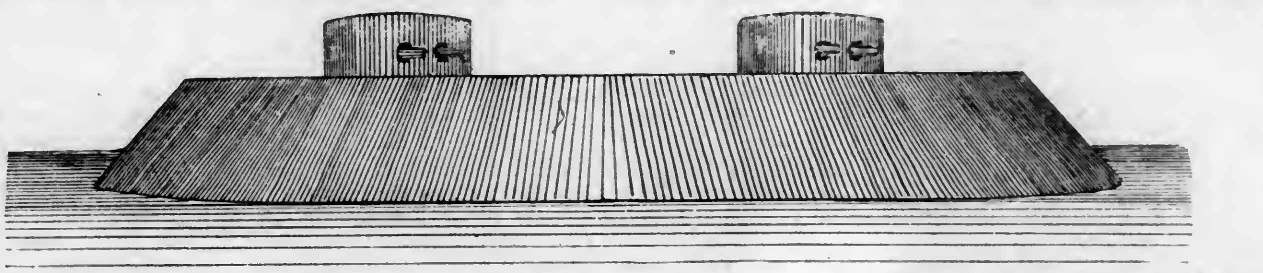


Fig. 3 represents a two-turreted armored structure that has been proposed for the present site of Fort Lafayette in New York Harbor.

XXIII.—HOW GENERALLY EMPLOYED FOR LAND DEFENSE.

The character of the fire to which a particular work is likely to be subjected will, in a great measure, determine the material to be employed in its construction. For sea-cost works, against which the fire of the heaviest guns may be brought, but which are only likely to be called upon to endure such fire for brief periods and for a few rounds, cast iron is, no doubt, the coming metal ; but for an inland fort, against which may be concentrated the prolonged and accurate fire of batteries of position, even though from guns of smaller caliber, this metal is hardly to be depended upon, and steel is likely to take its place. Although the Schumann cupola of wrought iron has been largely employed upon the Continent for inland defense, and owing to the peculiar form of the shield has given good results when subjected to fire, an equal resistance with much less weight could be obtained were steel employed instead—an important consideration.

It is, of course, no easy matter to obtain accurate information concerning the defenses of a foreign power. These matters are guarded with jealous care, and although we know the general system followed by most European powers, the same cannot be said regarding the actual disposition of works of defense. Paris, for instance, is surrounded by an outer circle of forts, with a perimeter of some 70 miles, but only in a general way have we information concerning them. So far as known they are of earth, of great profile, guns in barbette, and strengthened in some cases with revolving turrets at the salients. In Spain turrets have been proposed for the protection of Cadiz harbor, and in Portugal for the mouth of the Tagus ; but no work has as yet been done in either case. Italy is constructing Grüson cupolas for sea-coast defense, and also chilled iron casemates for the forts on her Alpine frontier. Germany, Austria, Russia and Holland use Grüson chilled iron armor, principally for sea-coast defense. For inland forts the Schumann cupola is, in Germany, more generally adopted. Belgium has followed the lead of France in the use of the cylindrical wrought-iron turret. It is now proposed to substitute steel entirely for all armor-plate. It is understood that the French have under construction on their frontier one of Mougin's underground forts previously referred to, and also that Bel-

gium has likewise determined upon building works of this character.

XXIV.—CONCLUSION.

Perhaps these papers upon armor development can be ended in no better way than by brief mention of the recent tests of armor-plate at Annapolis. This trial was remarkable not only on account of the results obtained, but also from the facts that it was the first time an American high-power gun had been called upon to face first-class armor-plate; that the gun and plates were fairly matched, and that the plates were the best of their kind, representing not only the two rival systems that have been struggling for supremacy since 1877, but also a new claimant for the favor of the metallurgist.

Without going into the details of these trials, which are already pretty well known, it may be said that they were brought about not so much to test armor-plate as the quality of the Holtzer chrome-steel projectiles. The plates purchased for this purpose were made by Schneider & Company. At the solicitation of Cammell & Company, Sheffield, that the test be made a competitive one between the English compound and the French all-steel, the Navy Department decided to purchase a Cammell plate and to open the competition to all comers.

Only three plates were presented for trial—none of domestic manufacture being ready—(1) a Schneider, oil-tempered, all-steel plate, containing $\frac{1}{4}$ of 1 per cent. of carbon; (2) a Schneider nickel-steel (an alloy of 96 per cent. of steel and 4 per cent. of nickel), and (3) a Cammell compound plate, Wilson's patent. The French plates had a thickness of 10.5 in., the English of 10.6 in. These were arranged in a semicircle 30 ft. in front of the gun; were backed by 36 in. of solid oak, well braced, and supported by a bank of well-rammed earth. The gun was a 35-caliber 6-in. navy, specially made for these trials and used a $44\frac{1}{4}$-lb. charge of American brown cocoa powder, and gave its projectiles a velocity of 2.075 ft., with a striking energy at the muzzle of 3,300 foot-tons. The projectiles were forged chrome-steel shell, made by the French firm of Holtzer & Company, to test which these experiments were brought about. They were 17 in. in length, and weighed 100 lbs. each.

The test was to be a shot from the 6-in gun delivered at each of the four corners, at a point 2 ft. from the horizontal and vertical edges, and a final shot from an 8-in. gun delivered in the center. The details are as follows:

Schneider All-Steel Plate.—The first shot entered the plate about three-quarters its length and there remained, apparently little injured; no cracks beyond surface fissures around shot-hole. The second and third shots penetrated the target about 12 in., the points coming through and bulging out the back; the projectiles rebounded in both cases, both slightly shortened, and one set up about 0.01 in; both had received a high polish at the point, and both, by the restoration of the copper band, might have been fired again. The fourth shot broke up after penetrating about the same distance as the two previous shots. Except for the shot-holes and a few surface fissures, the plate was apparently uninjured, and its resisting powers almost as good as at the beginning.

The Schneider Nickel-Steel Plate.—In the first and fourth rounds the projectiles barely got their points through the plate and broke up, leaving their points in the target. In the second and third rounds the projectiles were embedded in the plate, their bases projecting about $2\frac{1}{2}$ and $3\frac{1}{2}$ in. from the face of the target. Beyond some splintering off of metal, where the projectiles entered, the plate was as smooth and free from cracks as at the beginning. Two bolts were started by the second shot.

The Cammell Compound Plate.—The first shot went through the plate and 11 in. into the oak backing, some bolts were started, a small piece of the steel facing broken off, and seven serious cracks opened. At the second round the projectile penetrated the plate, went into the backing and broke up, sent out cracks to the hole made by the first shot, opened the cracks already formed, and started the steel face from the wrought-iron back. The third shot went through the plate and into the backing, setting it on fire; the upper right-hand corner was a mass of cracks, which seemed to extend through the plate. At the last round the projectile went through plate, backing, earth and into the hill-side beyond, broke off about one-fifth of the steel face to a depth varying from one-third to one-half of its thickness, and cracked its whole surface. The plate was practically a wreck.

This trial took place on September 18; on September 22 the final test was had by firing one shot at each plate from the 8-in. gun. The projectile was a 210-lb. armor-piercing shell made by Firth, of Sheffield, after the Firminy process, which, by the way, is the process employed in the manufacture of the American-made shell to be tested during the present autumn. A reduced charge of 85 lbs. of powder was used, giving a velocity of only 1,850 ft.

The first shot from the 8-in. gun was against the Schneider all-steel plate. The projectile went entirely through the steel and $4\frac{1}{2}$ in. into the oak backing, rebounded and broke into three nearly equal parts. From the hole made by this shot, four small cracks radiated, one to each of the holes made by the 6-in. shot, and continued in 8 straight lines to the edges. The plate remained upon its backing. The shot against the nickel-steel plate penetrated about 20 in. and was badly broken up. There were no cracks anywhere upon the plate beyond a few surface checks around the shot-holes. Apart from the shot-holes, the plate seemed as serviceable as when first put up. The final shot against the Cammell plate tore a hole through the center of the plate, the oak backing, and lodged some 12 ft. in the packed earth behind. The projectile was apparently uninjured. Pieces of the plate were sent flying a thousand yards to the rear, its entire face was stripped off to the depth of 4 or 5 in., except a few small pieces at the sides, and even these were loosened.

When taken from their backings and examined by the Trial Board, it was found that the back of the all-steel plate was in better condition than had been expected—the four cracks radiating from the central shot only extending through in places, and that the plate could still support its own weight. The back of the nickel-steel plate had no cracks except where the metal had been bulged out by the projectiles. The back of the compound plate likewise had no cracks extending through the wrought iron, except about the shot-holes.

The wood backing behind the two steel plates was not even splintered, a dent showing where the points of the shot had gone through—that of the all-steel having the better appearance. The backing of the Cammell plate was badly shattered.

A fact worthy of note is that the heat developed by the impact of the Holtzer projectile against the all-steel plate was sufficient to blister the paint upon its surface some inches from the shot-hole, clearly showing the capability of this plate of taking up and converting into heat a very appreciable amount of the destructive energy of the projectile—a claim particularly made for relatively soft steel plates.

That the coming armor-plate is to be of steel nickel alloy can hardly be asserted from the results of a single trial; that it will be thoroughly tested, the appropriation of a million dollars for the purchase of nickel ore and pig clearly testifies. The details of its manufacture are not known outside the foundry where it was made, while the exact influence of nickel upon steel, and the best proportion of nickel alloy for armor-plate, are as yet, we believe, largely a matter of theory. A fragment of the metal before us, a splinter from the point of impact, shows it to be of fine, even structure, its color indicating how thoroughly the heat developed by concussion had drawn the temper. Nickel-steel certainly seems to possess in a high degree that desideratum so long sought for in armor-plate—hardness without brittleness.

The fact that the 6-in. gun made for this trial, together with its mountings, was turned out at the Washington Gun Foundry in 55 days from the time the rough-turned forgings were taken in hand, shows how great has been the advance in gun construction since the first built-up American gun was turned over for trial in 1884 from these shops.

The battle between the gun and the armor-plate has been going on for more than 30 years. From the $4\frac{1}{2}$ in. iron armor of the *Warrior* to the 18 inches of tempered steel

upon the sides of a modern battle-ship, the step is, perhaps, no greater than between the reinforced cast-iron Lancaster rifle and the latest forged steel built-up Krupp, Canet or American gun. Nor has the contest at any time been greatly unequal. The dead and the disabled on both sides are to be found about the yards and upon the scrap heaps of every ordnance proving ground of both continents. To-day the gun is unquestionably in the lead, and when we have the announcement that an initial velocity of 2,550 foot-seconds has been obtained from a 9.45-in. Schneider all-steel rifle, using smokeless powder, with perfectly safe powder pressures, we find it hard to conceive that any known metal or combination of metals, of practicable thickness, can successfully stand up before the enormous energy which such high velocities imply.

WEAR OF METALS AS INFLUENCED BY THEIR CHEMICAL AND PHYSICAL PROPERTIES.

By Dr. Charles B. Dudley.

(Paper read before the joint meeting of the Iron & Steel Institute and the American Institute of Mining Engineers.)

In October, 1878, and again in February, 1881, I had the honor to make public, through the medium of the American Institute of Mining Engineers, the results of an extended study of steel rails which had been in service, and which were taken for the purpose from the tracks of the Pennsylvania Railroad Company. These studies appeared in three papers. In the first of these papers the question of what kind of steel is least liable to fracture or disintegration in the track was the principal one considered. In the second paper the question discussed was, Does the power of steel to resist wear increase with the hardness? In the third paper the relation between wear and the chemical and physical properties of the metal was the principal point considered. The general results arrived at, or the conclusions reached, were as follows: 1, that a mild steel is less liable to fracture, and, if properly made, less liable to crushing or disintegration in the track than a harder steel; 2, that the wearing power of steel in rails not only does not increase as hardness increases, but, on the contrary, diminishes; or, in other words, that a mild steel gives less loss of metal under the same service than a hard steel.

My own criticism of this work, after the lapse of 10 years, and after all the discussion which followed the publication of the papers above mentioned, may, perhaps, be fairly summed up in four conclusions:

1. If I had the work to do again I would certainly determine the sulphur in the rails, since all our studies during the past 10 years on the influence of sulphur point strongly in the direction of indicating that the sulphur has an important influence on steel, especially in its effect on the carbon.

2. The influence of silicon, and especially its influence from the metallurgical standpoint, seems to be much better understood now than at the time when these studies were begun, and if an ideal formula, representing our views as to the best possible composition for steel rails, was to be made at the present time, the silicon limit would be raised somewhat, possibly to the favorite figure of Mr. Sandberg—namely, 0.10 per cent.

3. It is possible that in the first paper published the influence of the chemical composition on what is commonly known as crushing or disintegration of rails in the track was made more prominent than the facts would warrant. More mature or riper studies would seem to indicate that disintegration or crushing of steel is hardly a resultant of lack of soundness in the ingot, and is more mechanical than chemical, except in so far as chemistry may be responsible for the soundness of the ingot. However, upon this point of sound ingots, we have seen little reason to modify the views held for some time, that time is more important in securing sound ingots, especially time in certain critical parts of the process than any other single element. If our views are correct, sound ingots, with consequently sound rails, can be made from steel of varying composition, provided time is allowed at the right points in the process, and the claim that high manganese and high carbon are essential to secure sound ingots is, in our judgment, not well founded, provided that time enough is allowed to make the steel properly.

4. In all our later studies on the wear of metal we have, as far as possible, avoided a method of deciding which metal is best which attempts to give what may be called absolute results. In other words, loss of metal by wear, per million tons, has some necessary errors in it, and, accordingly, in our later studies we have adopted this method of comparison: Two metals of different composition are subjected as nearly as possible to the same wear, and the one which wears the faster, by comparison with the other, is regarded as the poorer, as will be explained a little later. It would, perhaps, have been difficult to use this method on rails selected from different portions of the track, the extremes being somewhere about 100 miles apart, but if we had the work to do again a strenuous effort would be made to use the method of comparison. Of course, this is possible where direct positive experiments are made.

One point further in regard to the work already done on this subject. Samples of all the rails which were discussed in the third paper, above mentioned, have been carefully preserved with the idea in mind of some time repeating the work, with the improved means and methods which time and study in the realm of chemical metallurgy should place in our hands. Especially has it been hoped that some methods of chemical analysis would be devised which would enable us to determine, not only the total amount of carbon, phosphorus, silicon, manganese, sulphur, etc., in these various steels, but also how these substances were combined. For example, does the phosphorus in any given rail exist as phosphide, or partly as phosphate, or both? Is the silicon simply alloyed, or chemically combined with the iron? Does the carbon all appear as strength carbon, or is some of it graphitic, or combined with the iron in such a way as to form a crystalline body which adds nothing to the strength? The 10 past years have done something in unraveling these mysteries, but hardly enough, we think, has been developed as yet to enable us wisely to re-examine these rails. It has been our belief for some time that no decided step forward in the chemical metallurgy of steel could be taken until we have solved some of the questions as to how the various impurities which occur in steel exist in the metal, and we may add that it is not from lack of interest in the subject, but from necessary devotion to study in other lines, that our own work in this field, and our possible contributions to knowledge on this subject, have been so small.

Otherwise than as regards the criticisms above mentioned—namely, that the sulphur should have been determined, possibly the silicon limit raised a little, the influence of the method of manufacture on the final product made a little more prominent, and the comparative method used as far as possible in determining the difference between good and poor rails—we have seen little occasion to modify the conclusions stated in the papers as published—namely, that mild steel is not only safer for rails and for other constructive purposes, but also that mild steel gives better wear, or loses less metal under the same traffic, than harder steel. It seems quite probable that this conclusion will hardly be accepted by the mass of engineers, or by those who are engaged in metallurgical industry, and the object of this paper is simply to bring up to date the additional information which has been accumulated on this subject during the past 10 years. Meanwhile, what light has the past 10 years thrown on the special subject of the relation between wear and the chemical and physical properties of metal?

1. Since the papers above referred to were published no systematic study of steel rails has been attempted in the Pennsylvania Railroad Laboratory.

2. It will be remembered by those who are familiar with the discussion which followed the publication of the papers on steel rails, that some trial rails, according to the formula suggested in the first paper, were made in Germany, and inspected by Mr. Sandberg, who made his work the subject of a contribution to the discussion. The place where these rails went into service never came to my knowledge until a little over a year ago. At that time I

received a letter from Mr. P. H. Conradson, the Chemist of the New York & New England Railroad, stating that he had found in the records of that road that 2,500 tons of steel rails, in accordance with the formula suggested in the first steel-rail paper above referred to, had been made at Gütehoffnungshütte, Germany, and had been laid on their road. Mr. Conradson's letter gave the formula on which the rails were ordered, which is practically the formula of my first steel-rail paper, and also states that the records show a number of reports of inspection, signed by Mr. Sandberg, with analyses made by Mr. Magnus Troilius. A number of analyses are also given, taken from the tests of inspection, showing, in general, that the rails came within the limits of the specifications—namely, in no case was carbon above 0.35 or below 0.25 per cent.; manganese was in no case above 0.40 or below 0.30 per cent.; phosphorus was between 0.055 and 0.075 per cent., and silicon varied from 0.01 to 0.08 per cent.; most of them being about 0.05 per cent. The physical tests were also fairly close to the assigned limits of the specifications—namely, they were generally within 75,000 lbs. tensile strength per square inch, with not less than 20 per cent. elongation, the limits being from 73,000 to about 80,000 lbs. tensile strength per square inch, and 17 to 23 per cent. elongation. The rails weighed 60 lbs. per yard, and were put in the track where they could be subjected to the severest service. They remained at this point seven years, and were taken up to be replaced with a heavier rail. Upon receipt of Mr. Conradson's letter, the matter was brought forward with the officers of the road, with the idea in mind of obtaining positive figures as to the tonnage which had passed over the rails during the seven years, but although data on this point was promised, yet, owing to changes in the management, it was never furnished. We are, therefore, without positive data, expressed in figures, as to how these rails wore. The statements, however, of those most familiar with the rails while they were performing their service were to the effect that they were in every sense satisfactory, and that they gave excellent results. The words of the one most competent to judge, quoted by Mr. Conradson, are as follows: "These rails have not changed any during these seven years of continuous use so that it can be detected by the naked eye." It would be gratifying to have positive figures as to the tonnage and loss of metal by wear, but in the absence of this data it is perhaps not too much to say that even if we do not have from it so positive a confirmation of our views as could be desired, there is certainly nothing in the data to controvert the idea that mild steel gives better wear in rails than hard steel.

3. I am aware of the conclusions reached by M. Verschovsky, Engineer-in-Chief of the Russian State Railroads, which were stated in a paper read before the Railroad Congress in Paris in 1889. Those who have read this paper know that the conclusions reached by M. Verschovsky seem to be directly opposite to the conclusions which we have reached—namely (if we can trust the translation which I have), "the best wearing rails have the greatest tensile strength with the least elongation;" and again, that the "rails which broke were softer, as far as indicated by tensile strength and elongation, and there is a difference between a hard rail and a brittle one." Still further, as regards the chemical composition, "the best rails contain more carbon and manganese than the brittle ones, and in all cases much more silicon and less phosphorus." In the absence of data as to what constituted the best rails—that is, as to how the best rails were decided on—and in the absence of any positive data of loss of metal by wear, it is, of course, exceedingly difficult to criticise or explain the conclusions obtained by M. Verschovsky. However, one point in the paper seems to throw some light on the possibilities of the case. It is stated that, in consequence of the specifications issued by the Government, the steel works did all in their power to produce a soft steel, so as to insure that the "frozen rails should stand the falling or drop test prescribed," and that this result was accomplished, but that, as a concomitant of this soft steel, a new difficulty appeared, which was that after a few months of wear the rails began to crush or flatten at the ends, so that in a short time replacement was found necessary. To our minds this seems to indicate that as the result of the effort of the steel works to produce soft steel, very unsound or porous ingots were obtained, which produced rails that were not sound and homogeneous, and which would be likely to behave exactly as M. Verschovsky describes. It will be remembered that this difficulty of getting sound ingots with soft steel was largely the burden of the discussion which followed the publication of the steel-rail papers, and it seems fairly probable that the difficulty which M. Verschovsky describes may be entirely due to this cause. If the steel works, in trying to make the soft steel, so hurried the process that unsound and porous ingots were obtained, we see no difficulty in accounting for the conclusions which M. Verschovsky has reached.

4. Several years ago our attention was directed to the question of tires on locomotive driving wheels, which, as is well known, are made of steel. The question under discussion was the possibility of preparing specifications for locomotive ties, and, as a preliminary study, examination was made of a number of steel tires which had been in service. It may be stated here that for a number of years past the practical men in charge of the lathe shops on different portions of the Pennsylvania Railroad where tires are turned off noticed, and have stated in conversation, that they always had to turn off the most metal from the softest tire; that is to say, when the tires come into the shop for re-turning the very hard tires were the ones which had worn the most, the hardness being determined by the behavior of the tool during turning. This, of course, was simply an observation, and very little positive data could be drawn from it. A number of tires were taped as they came in from service to be re-turned, and in a short time three pairs of tires were found which showed marked differences in circumference. The circumference was measured by putting a tape around the tire. In one case the difference in circumference was 2 in., and in each of the other cases the difference was 1¾ in. This difference in circumference corresponds to a difference in diameter of from 0.55 to 0.63 in., or from 0.27 to 0.31 in. in the thickness of the tire itself. In other words, by actual measurement of tires which had been in service on opposite ends of the same axle, which were of the same diameter and circumference when they went into service, in the case of two of the pairs, one of the two tires had lost a little over ¼ in. of its thickness more than the other, while in the other pairs one had lost nearly ¼ in. more of its thickness than the other. In view of this discrepancy in wear under as nearly as possible the same conditions, it was with a good deal of interest that analyses were made of the metal taken from these tires. The results of the analyses are as follows:

Analyses of Unequally Worn Tires, from Opposite Ends of the Same Axles, on the Pennsylvania Railroad Locomotives.

	Least worn tire.	Most worn tire.
Engine 654.	Per cent.	Per cent.
Carbon	0.594	0.708
Manganese	1.076	0.938
Phosphorus	0.039	0.101
Silicon	0.245	0.143
	Least worn tire.	Most worn tire.
Engine 136.	Per cent.	Per cent.
Carbon	0.541	0.625
Manganese	0.880	0.974
Phosphorus	0.062	0.063
Silicon	0.253	0.153
	Least worn tire.	Most worn tire.
Engine 626.	Per cent.	Per cent.
Carbon	0.525	0.554
Manganese	0.512	0.714
Phosphorus	0.032	0.037
Silicon	0.179	0.208

The tires of Engine 654 had a difference in circumference of 2 in.; the other two had a difference in circumference of 1¾ in. It is interesting to observe that in every case the carbon is lowest in the least worn tire, indicating the softest steel, so far as carbon is concerned. Again, in two of the three the manganese is lowest in the least worn tire. In one of the three there is quite a difference in phosphorus, the lowest being characteristic of the least

worn tire, the other two having very slight differences in phosphorus. In two the silicon is highest in the least worn tire, while in the other the difference is the other way. Of course it is impossible to draw any very general conclusions from so small a number of samples as three, but the teaching of these results would seem to be that, in general, lower carbon and manganese and higher silicon are characteristic of tires which give the best wear. It is fair to say, in this connection, that it is not at all impossible that the temper of this steel may have an influence on the wear, apart from the chemical composition. It is well known that tires are "set," as it is called—that is, are fastened upon the wheel center—by having the tire turned out to a diameter a little less than that of the wheel center, and then heating the tire to expand it, so that it will take the wheel center, and then cooling the tire. If, now, the tires are not heated to uniform temperatures, and cooled uniformly, or if they differ somewhat in their carbon, it is probable that one tire would have a different "temper" or "hardness produced by cooling" than another, and this might have an influence on the rate of wear. Of course no positive data can be given on this point at the present moment. Before leaving the wear of tires, permit me one word further. Confining ourselves to the question of wear, it is difficult to conceive of anything which produces wear in rails different from that which produces wear in tires, since, if we understand rightly, it is a strain between the wheel and the rail which causes the rupture or tearing off of the small particles which we are accustomd to call "wear." It would seem, therefore, that tires afford an admirable opportunity for studying the question of relative wearing power of hard and soft steel, and the experiments alluded to already are the experiments on the wear of tires. It seems probable that within six months, or possibly a year, we may have considerably more light on the relative wearing power of hard and soft steel than we now have.

5. Our studies on wear have not been wholly confined to the behavior of iron and steel under abrasion or rolling friction. A very large number of experiments have been made on the Pennsylvania Railroad with various alloys used as bearing metals. If these may be trusted, and our deductions are correct, those alloys which are least brittle give the best wear—that is, lose less metal under the same conditions than harder, or more brittle alloys. Or, looked at in the light of definite physical properties, those alloys which give the slower wear are characterized by lower tensile strength and greater elongation than is characteristic of those giving more rapid wear.

The alloys experimented with have been principally the old copper-tin alloy—seven parts copper to one of tin—and alloys of copper, tin, and lead, with and without phosphorus and arsenic. The method has been to have a certain number of bearings made of a standard bearing metal—described later on—and the same number of the experimental metal. These bearings were placed on opposite ends of the same axles, either on locomotive tenders or cars, the axles so arranged that one-half of the experimental bearings were on one side of the car and one-half on the other side. The bearings were all carefully weighed before going into service, and after a sufficient lapse of time were taken out and reweighed. At first an attempt was made to give the loss of metal by referring it to the mileage, but the method of comparison was ultimately adopted, as giving results free from any possible difficulties introduced by mileage, so that all the results which we obtained are strictly comparative.

The standard bearing metal is what is known in this market as phosphor-bronze bearing metal, technically described by the Phosphor-Bronze Smelting Company as the "S. Bearing Metal." This metal contains approximately 79.70 per cent. of copper, 10.00 per cent. of tin, 9.50 per cent. of lead, and about 0.80 per cent. of phosphorus. It is, of course, a fair question, and one which has not been overlooked, whether the standard bearing metal gives uniform wear. A large number of experiments have been made on this point, the result being that the average wear of standard phosphor-bronze compared with the mileage, is best expressed by saying that the phosphor-bronze bearing metal loses 1 lb. of metal, worn off, for every 18,000 to 24,000 miles of travel. This, it will be observed, shows a discrepancy in the wear of the standard phosphor-bronze bearing metal, and the fact led us to abandon the method of making comparisons by mileage. The reasons for the discrepancy are not hard to find: First, the pressure per square inch in all tests were not the same, and consequently the wear would not be the same. On the other hand, with bearings on the opposite ends of the same axle, the pressures per square inch are approximately the same. Second, the state of the lubrication in different cars and engines, which is more or less characteristic of different parts of the road, is a very important variable, and undoubtedly goes far toward explaining the differences in mileage above given. This variation in the state of lubrication is not so apt to be characteristic of opposite ends of the same axle, as it is of different cars and locomotives. We are inclined to think, therefore, that the assumption that standard phosphor-bronze is sufficiently uniform in its behavior to warrant its being used as the basis of comparison will not lead us into serious error, at least if we confine ourselves to a direct comparison of the loss of metal obtained from standard bearings on one end of the axles and experimental bearings on the other end of the same axles. Usually 16 bearings of each kind were put in service as a preliminary experiment, and if the metal proved at all favorable on this preliminary trial, a larger trial, embracing 50 or 100 bearings of each kind, was put in service. The preliminary trials were usually made on locomotive tenders, where the bearings get the best possible care. The larger trials were more commonly made on cars. Of course, owing to the exigencies of the service, it sometimes happened that some of the bearings put in use were not returned to be weighed. This was more true where bearings became heated, and were removed at different points along the line, than at the regular inspection points. Whenever, from any cause, a bearing was missing, its opposite was not taken into account, so that in reality in the results given the comparisons are strictly between the same number of standard and experimental bearings on opposite ends of the same axles. Sometimes as high as one-half the bearings in an experimental lot would be lost. In other cases nine-tenths would be returned. The results of the tests, with the composition, and, so far as our knowledge goes, the physical properties of the various alloys tested, are given below. It is unfortunate that in the earlier tests the physical properties of the alloys were not taken. In the composition, approximately average analyses are given rather than a special analysis of the metal in each test, and it will be observed that there is no allowance made for the small impurities, such as zinc, antimony, iron, etc., which are usually characteristic of commercial metals used in making these alloys, especially where some scrap is used in making the bearings, as is almost always the case. It will also be observed that in all cases, in expressing the loss of metal by wear, the results are given in percentages of the metal lost by the standard phosphor-bronze.

COPPER-TIN VERSUS PHOSPHOR-BRONZE.

	Composition copper-tin. Per cent.	Composition phosphor bronze. Per cent.
Copper	87.50	79.70
Tin	12.50	10.00
Lead	None.	9.50
Phosphorus	None.	0.80

Wear.—First experiment, copper-tin wore 48 per cent. faster than phosphor-bronze; second experiment, copper-tin wore 53 per cent. faster than phosphor-bronze; third experiment, copper-tin wore 47 per cent. faster than phosphor-bronze.

ARSENIC BRONZE VERSUS PHOSPHOR-BRONZE—FIRST EXPERIMENT.

	Composition arsenic bronze. Per cent.	Composition phosphor-bronze. Per cent.
Copper	89.20	79.70
Tin	10.00	10.00
Lead	None.	9.50
Phosphorus	None.	0.80
Arsenic	0.80	None.

Wear.—Arsenic bronze wore 42 per cent. faster than phosphor-bronze.

Arsenic Bronze versus Phosphor-bronze—Second Experiment.

	Composition arsenic bronze. Per cent.	Composition phosphor-bronze. Per cent.
Copper	89.20	79.70
Tin	10.00	10.00
Lead	7.00	9.50
Phosphorus	None.	0.80
Arsenic	0.80	None.

Wear.—Arsenic bronze wore 15 per cent. faster than phosphor-bronze.

Arsenic Bronze versus Phosphor-bronze—Third Experiment.

	Composition arsenic bronze. Per cent.	Composition phosphor-bronze. Per cent.
Copper	79.70	79.70
Tin	10.00	10.00
Lead	9.50	9.50
Phosphorus	None.	0.80
Arsenic	0.80	None.

Wear.—Arsenic bronze wore 1 per cent. faster than phosphor-bronze.

Damascus Bronze versus Phosphor-bronze.

	Composition Damascus bronze. Per cent.	Composition phosphor-bronze. Per cent.
Copper	77.00	79.70
Tin	10.50	10.00
Lead	12.50	9.50
Phosphorus	None.	0.80

Wear.—First experiment, Damascus bronze wore 8 per cent. slower than phosphor-bronze; second experiment, Damascus bronze wore 7.30 per cent. slower than phosphor-bronze.

	Composition Alloy "B." Per cent.	Composition phosphor-bronze. Per cent.
Copper	77.00	79.70
Tin	8.00	10.00
Lead	15.00	9.50
Phosphorus	None.	0.80

Physical Properties.

	Alloy "B."	Phosphor-bronze.
Tensile strength, per square inch, lbs	24,000	30,000
Elongation, per cent	11	6

Wear.—Experimental alloy "B" wore 13.50 per cent. slower than phosphor-bronze.

If we interpret the above results correctly, they indicate: 1, that copper-tin wears nearly 50 per cent. faster than standard phosphor-bronze; 2, that arsenic bronze, containing no lead, wears about 42 per cent. faster than phosphor-bronze; 3, that arsenic bronze containing 7 per cent. of lead wears less rapidly, the exact figure being 15 per cent. faster than phosphor-bronze; 4, that arsenic bronze containing the same amount of lead as phosphor-bronze wears but slightly faster, the figure being 1 per cent.; 5, that Damascus bronze containing as high as 12.50 per cent. of lead wears from 7 to 8 per cent. slower than phosphor-bronze; and, 6, that the experimental alloy "B," containing less tin and more lead than any of the other alloys experimented with (the figures being 8 per cent. of tin and 15 per cent. of lead, instead of 10 per cent. of tin and 9.50 per cent. of lead, as is characteristic of phosphor-bronze), wears 13.50 per cent. slower than phosphor-bronze. This last alloy is the only one of which we have the physical properties compared with phosphor-bronze, and it will be observed that it has considerably lower tensile strength with greater elongation than the phosphor-bronze. This characteristic of lower tensile strength and greater elongation, it will be remembered, is the same characteristic which has been so often alluded to in the case of steel—namely, the mild steel, which, as is well known, is characterized by lower tensile strength and greater elongation than harder steel, gives the best wear. Here, too, in the realm of alloys, that metal which gives the lower tensile strength and greater elongation, if our experiments can be trusted, gives the slower wear. As has already been stated, it is unfortunate that the physical tests of all the other experimental alloys were not taken; but there is another method of getting at the physical properties of these alloys which is instructive, and although not as definite, is, perhaps, almost as convincing as though the actual figures were given. It is well known that the alloy of two parts of copper to one of tin, which is commonly called speculum metal, is one of the most brittle substances known. If, now, the percentage is changed, and an alloy is made of three parts of copper to one of tin, it is less brittle than the first one. Four, five, six, seven, eight, etc., parts of copper to one of tin give alloys which are in every case less and less brittle, as the tin diminishes, if our data can be trusted. It is well known that the alloys of four, five and six and sometimes seven parts of copper to one of tin are used for making bells for various purposes. The alloy of seven parts of copper to one of tin is the copper-tin alloy used as bearing metal in our experiments. If this reasoning is correct, the law seems to be that the increase in copper and the diminution in tin, at least within the range of our experiments, give alloys which are less and less brittle in every case. In the experiments which we have made it will, of course, be urged that lead comes in as an important constituent in the alloy, and consequently the query arises, What influence has the lead on the alloy? The influence of the lead has not been worked out in figures to our knowledge, but so far as our observation and study have gone, the addition of lead practically amounts to the same thing as a still further diminution of tin; that is to say, an alloy containing any given percentage of copper and tin will be rendered more ductile and less brittle by the addition of lead to this alloy, which, if our reasoning is correct, is the result which follows a diminution of tin and an increase of copper. I have, in another place, tried to illustrate this subject at some length, and will not therefore, at this time, dwell longer upon it, except to say that in the only case in which we have a physical test of these alloys—namely, in the case of phosphor-bronze and the experimental alloy "B"—this law seems to be fairly well illustrated. In the standard phosphor-bronze, the ratio of copper and tin is very nearly 1 to 8, while in the experimental alloy "B" the ratio of copper and tin is about 1 to 9.6. The percentage of lead in phosphor-bronze is 9.50, and in the experimental alloy "B" 15 per cent. The marked influence of these changes on the tensile strength and elongation is very clear. The tensile strength is cut down 6,000 lbs. per square inch, or about one-fifth, and the elongation is increased to nearly double that of phosphor-bronze. I will add for information that the experimental alloy "B," with a slight modification so as to enable the foundry to use the large quantities of phosphor-bronze scrap which the Pennsylvania Railroad possesses, and which results in giving from 0.10 to 0.20 per cent. phosphorus in the finished bearing—the percentage of the other constituents being those given above—is now the standard bearing metal of the Pennsylvania Railroad, and no information has been obtained, during some six years of constantly increasing use of this metal, which would controvert the conclusion given above, that the experimental alloy "B" wears slower than standard phosphor-bronze. It is possibly hardly necessary to add that we are not able to draw from our experimental work in the realm of alloys any other conclusion than that those alloys which are least brittle, or, measured in technical language, which have lower tensile strength and greater elongation, give better wear as bearing metal than those alloys in which the reverse is the case; or, in other words, that in the realm of the alloys, so far as our experiments have gone, the same thing holds true which we have therefore found in regard to steel—namely, the softer the metal the better wear it gives.

A few points further in regard to wear. We are not aware that any attempt has ever been made to formulate the variables on which wear depends; or, in other words, to enunciate a theory of wear, and it is entirely possible that the data in our hands, which are reliable enough to be so used, are not at all sufficient to warrant us in making such an attempt. Our observations, however, have led us to philosophize on this subject, and at the risk of

saying something which future experiments may very greatly modify, or possibly show to be fallacious, we will venture to state a few of the variables which enter into wear.

Of course, wear is influenced by the conditions under which it takes place, but it is not our purpose to discuss these variables which may fairly enough be called "concomitant conditions." We will therefore not discuss lubrication, pressure, speed, temperature, rolling friction, or abrasion, nor indeed the nature of the two metals rolling or sliding over each other, but will confine ourselves wholly to the qualities of metal, which, all other things being equal, give least loss of substance by wear under the same service. To our minds we are justified in assuming that at least three elements enter into the problem of wear:

1. That metal which will suffer the most distortion without rupture will wear best. This quality of metal is usually measured or expressed in figures by the well-known physical data "elongation" or stretch before rupture in the common physical test. Possibly the experimental data on this point are greater than we possess on any other of the variables which enter into wear. If we may trust the data which we have brought forward, and the conclusions drawn from them, in all cases the greatest elongation is characterized by the best wear; or, according to the law, that metal which is characterized by the greatest power to resist distortion without rupture will wear best.

2. The first variable being obtained in satisfactory amount an increase in tensile strength will add to the wearing power of the metal. The diminution of tensile strength, which is characterized by the better wearing metals, according to our data, is not, if we are correct, a desirable quality. It is a concomitant of most metal that as it increases in its power of elongation, or stretch, before rupture, it diminishes in tensile strength. If, on the other hand, a new metal could be found, which, with any given elongation, was characterized by a higher tensile strength than some old and well-known metal with the same elongation, the new metal would, if the theory is correct, wear better than the old one. It is not difficult to say why an increase in tensile strength should be valuable in assisting wear, provided the power of distortion before rupture is not interfered with. Wear, as we understand it, is the tearing off of minute particles, and if in one case it requires more force to tear off the particles than in another, the wear in that case will be slower. We have, we think, a little experimental data which points in this direction. The wear of bearings per thousand miles is about three times as fast as the wear of axles; in other words, as has already been stated, the standard phosphor-bronze bearing metal loses about a pound for each 25,000 miles that the bearing moves. The axle under it loses about a pound for each 75,000 miles, but the metal of the axle is from two to three times as strong per square inch, and its elongation is also somewhat higher than the bearing metal alloy.

3. The third variable which enters into wear, as we look at it, is what may perhaps be termed the "granular structure of the metal." This may, perhaps, best be illustrated by saying that, of two metals which have the same tensile strength and the same elongation, the one which is finer in granular structure will wear the slower. This we think will be evident by returning to our conception of what wear is—namely, the tearing off of minute particles from the worn body. If, now, at each rupture of a particle of metal, the particle torn off is in one case twice as large as in the other, the wear will be twice as rapid, and we assume that, other things being equal, the granular structure represents the size or fineness of the particles torn off at each operation during wear. We have but little experimental data on this point. It is generally believed by those who have a chance to make observation that what is known as case-hardened iron wears better than either the wrought iron from which it is made or than ordinary hammered steel of approximately the same carbon. It has also been observed that case-hardened metal is always characterized by an extremely fine granular structure, as evidenced by the fracture. This, of course, is only an observation, and cannot be taken as proving very much. It is also entirely possible that the influence of what is technically known as "tempering," on wear, may appear in the effect of the temper on the granular structure. The field is, of course, too void of experiment and too little known to warrant anything more than suggestions.

The relation and interaction, so to speak, of the three variables mentioned above is, of course, quite an unknown field. We are inclined to think that the experimental data which have been obtained point clearly to the conclusion that the increase in tensile strength at the expense of elongation is disastrous, as far as wear is concerned. An increase in tensile strength with an increase in elongation would unquestionably, we think, be valuable. The influence of the structure or granular condition may be even more important than either elongation or tensile strength. Of course the data do not warrant any conclusions, but it seems not at all improbable that the size of the particle torn off, each time one is torn off, may be the most important variable in the rate of wear. It is also not improbable that if some method of measuring the granular structure of metal, and rightly estimating its influence on wear, was known, this information would go far toward explaining many of the anomalous cases of wear, which, if our experience is worth anything, are almost universal accompaniments of experiments in this field.

The whole subject of the relation between wear and the chemical and physical properties of metal needs study and positive experiment, and it is quite possible that much that we are accustomed to rely on at the present moment may be upset or overthrown by wider knowledge. The best we can say at present is that, with the light which we have, the highest tensile strength, accompanied by the highest elongation and the finest granular structure, are the physical properties which will probably give the best results in actual service where the metal is subjected to wear, and that that chemistry which will give these results in the finished product, be it in the realm of the alloys, or in the magnificent field of steel metallurgy, or, possibly, in the coming field of a metallurgy based on aluminum, is the best chemistry which we, at the present moment, are able to recommend.

Foreign Naval Notes.

THE accompanying table, compiled from figures recently published in London, gives the number of war ships of modern type owned or under construction by the principal nations of

Country.	First-Class Ships. Battle-ships.	Armored Cruisers.	Coast Defense.	Total.	Cruisers. Protected.	Unprotected.	Total.	Torpedo Vessels. Torpedo Cruisers.	Torpedo Boats.	Total.
England:										
Built up to 1890.	47	12	11	70	44	38	82	46	86	132
Now building.	10	....	....	10	41	....	41	....	....	....
France:										
Built up to 1890.	19	9	21	49	11	41	52	39	78	117
Now building.	4	5	5	14	5	....	5	...	...	....
Germany:										
Built up to 1890	7	5	15	27	2	20	22	24	94	118
Now building.	4	....	9	13	8	2	10	....	....	....
Austria:										
Built up to 1890.	11	....	....	11	1	9	10	12	23	35
Now building.	....	...	...	...	2	1	3	....	....	....
Italy:										
Built up to 1890.	19	....	...	19	8	12	20	22	61	83
Now building.	5	. .	....	5	7	...	7	....	....	....
Russia:										
Built up to 1890.	12	6	18	36	3	26	29	15	50	65
Now building.	3	2	1	6	2	4	6	....	...	....

Europe. Only those are included which have been built since the construction of armored vessels began. The first-class ships include the heavy battle-ships, fighting cruisers, rams and

floating batteries; the cruisers those over 1,000 tons built especially for cruising service; the third-class those built for torpedo service only.

It will be seen from this table that protected cruisers apparently meet with most favor, as there are few of the unprotected class now under construction; only 7 altogether, against 65 of the protected type.

It is stated that the total number of vessels of all classes which will be owned by the different nations in 1895—making no allowance for additions not yet proposed, or for losses which may occur in the mean time—will be as follows:

Nation.	Modern Types.	Older Types.	Total.
England	335	67	402
France	237	62	299
Germany	190	62	252
Austria	59	30	89
Italy	134	81	215
Russia	142	55	197

One item in the above tables may be changed very much before 1895, however; the future of the torpedo-boat must be considered very uncertain, as matters stand at present, and if results more favorable than are now expected should be obtained, their numbers may be considerably increased before 1895, since these vessels are generally small, and can be built in a comparatively short time. A battle-ship or heavy armored cruiser takes usually two or three years for its completion, and it is not probable that by 1895 there will be many more than indicated by the first table.

Quite a number of the English battle-ships were built before 1881, and are of types now considered out of date; some of the larger ones of earlier dates are bad ships to handle, slow and of doubtful efficiency in a seaway.

THE FASTEST CRUISER.

The first-class protected cruiser *Blenheim*, recently launched, is expected to be the fastest vessel of large size in the English Navy, her trial speed being fixed at 22 knots an hour.

The *Blenheim* is 375 ft. long, 65 ft. broad amidships and 38 ft. deep; her displacement is 9,000 tons on a mean draft of 25 ft. 6 in. Her engines, of the triple-expansion type, are expected to work up to 20,000 H. P.

The armor, weighing some 1,190 tons, is principally concentrated upon the protective deck. The hull is constructed of steel upon the usual cellular system. The hold-space is subdivided minutely by water-tight bulkheads and decks, and there is a cellular double bottom. The inner protective deck, which has for those looking into the interior from above the appearance of a second vessel encased in that which is visible from without, consists of a roof of curved steel covering the hold from stem to stern, the eaves of the roof, so to speak, being $6\frac{1}{2}$ ft. below, while the top rises $1\frac{1}{2}$ ft. above the water-line. This sharply curving deck is 6 in. thick over the machinery and engines, and 3 in. thick elsewhere. The vitals of the ship—the propelling apparatus, steering gear, magazine and shell-rooms—will all be beneath its protection. Tnere is no vertical side armor.

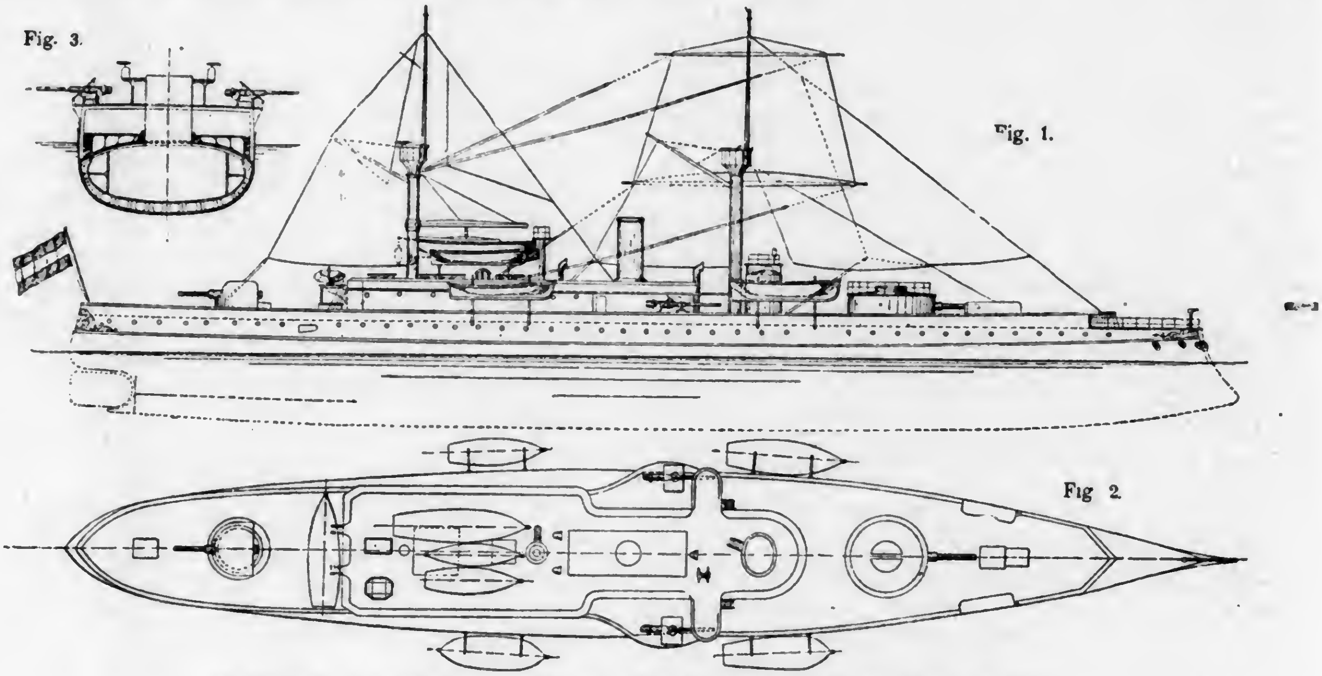
The armament will consist of two 24-ton guns mounted one forward and one aft; ten 5-ton guns, six mounted on the upper deck and four on the maindeck; sixteen 3-pdr. rapid-fire guns; one 1 in. and seven 0.45-in. Nordenfelt machine guns; four 14-in. Whitehead torpedo tubes.

The *Blenheim* was designed by Naval Constructor White; the hull has been built by the Thames Iron Works & Shipbuilding Company, and the engines by Humphrys, Tennant & Company. The trial speed of 22 knots is expected to give her an average sea speed of $18\frac{1}{2}$ knots in fair weather.

Fig. 3.

Fig. 1.

Fig. 2.



CRUISER "PRINCESS WILHELMINA" FOR THE DUTCH NAVY.

THE LATEST DUTCH CRUISER.

The accompanying illustration shows the protected cruiser *Princess Wilhelmina*, lately completed for the Dutch Navy. In this cut, which is taken from the *Mittheilungen aus dem Gebiete des Seewesens*, fig. 1 is a side elevation; fig. 2, a deck plan, and fig. 3, a cross-section of the ship.

The general dimensions of this vessel are: Length, 328 ft.; greatest breadth, 48.9 ft.; depth, 29.3 ft.; mean draft, 19.7 ft.; displacement, 4,600 tons.

The ship is sheathed with pitch-pine planking and copper sheathing to a point 4.26 ft. above the water-line at ordinary displacement. As will be seen from the drawing, she carries a center redoubt with armor 5 in. in thickness, and is further provided with an arched armored deck, which is also 5 in. in thickness outside of the redoubt. Above the armored deck the sides are protected with coffer-dams 30 in. in width, filled with cellulose. The turret on the forward deck has 11 in. of armor backed by 8.66 in. of teak, while the after turret or shield is also heavily armored and the pilot house at the forward end of the redoubt has 11-in. armor.

The main battery consists of one 11-in. breech-loading rifle in the forward turret; one 8.3-in. breech-loading rifle in the after end and two 5.7-in. guns carried in sponsons amidships and mounted on pivots, so as to give each a range of 180°. The secondary battery consists of six machine guns and eight rapid-fire cannon, two of the former being carried in the military tops on the two masts. There are also three torpedo tubes, two mounted amidships and one forward.

There are four engines, two on each propeller shaft. These engines are all of the vertical triple-expansion type, having cylinders 19 in., 31 in. and 51 in. in diameter and 27 in. stroke. Steam is furnished by four cylindrical boilers 14 ft. in diameter and 11 ft. long, built to carry a working pressure of 170 lbs.

An auxiliary boiler is provided to run the pumps and other auxiliary machinery.

The ship is provided with a full outfit for electric lighting, including search-lights, and there are two dynamos of equal size, so that the lights will not be cut off by injury to either one.

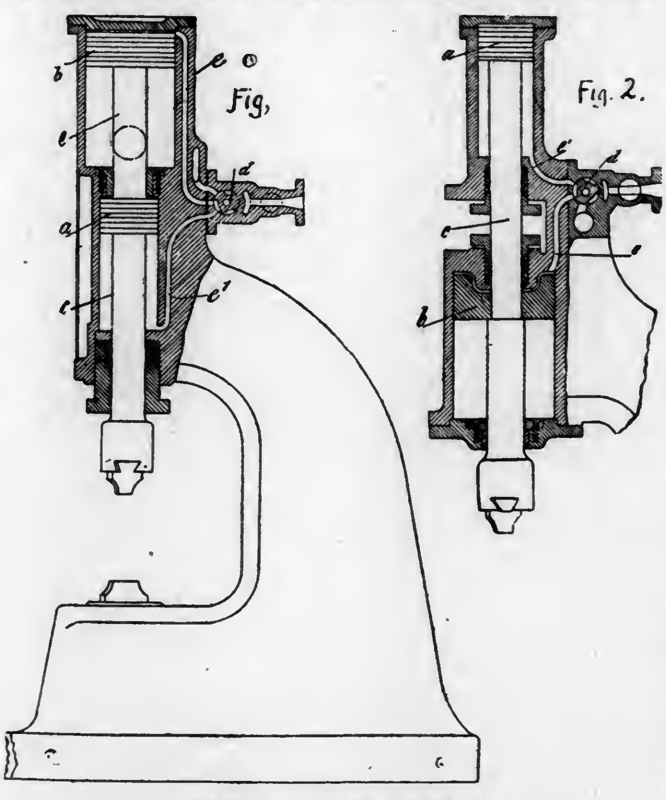
The ship has a double bottom, is divided into numerous water-tight compartments in the usual manner, and the coal bunkers are so arranged as to afford further protection. The normal coal capacity is 450 tons. The speed provided for is 16½ knots per hour with forced draft. At full speed the engines are expected to make 170 revolutions per minute, and to develop about 5,900 H. P. The crew will consist of 325 officers and men.

THE PORTUGUESE NAVY.

A recent decree providing for the reorganization of the Portuguese Navy has been made public. It will consist of 4 armored battle-ships for coast defense ; 10 protected cruisers from 3,500 to 4,500 tons displacement and a high speed ; 18 first-class gun-boats of 600 tons ; 12 second-class gun-boats, for colonial service, of from 150 to 300 tons ; 1 school-ship ; 24 torpedo-boats and 2 transport steamers of 3,500 tons. Two ships, the battle-ship *Vasca da Gama* and the transport *India*, are to be completed shortly, while the construction of the remaining three battle-ships, of six cruisers, 8 gun-boats, 20 torpedo boats and the school ship is to be begun immediately. In addition to the two ships mentioned above three gun-boats of the second-class are already in service in African waters, while one of the first and one of the second class are under construction. The old style vessels now constituting part of the fleet will be retained for the present, as it is considered that they will be useful as foreign cruisers and in colonial service. The type adopted for the cruisers somewhat resembles that of the Italian *Piemonte* and the English *Blake*. Where the new ships will be built is not yet known ; it will hardly be in English yards, as there is a very bitter feeling against that country in Portugal at present.

A Compound Steam Hammer.

THE accompanying illustration shows a compound steam hammer recently patented in England by Julius E. Reinecker, of Chemnitz, Saxony. The hammer shown is of the double-acting type, the upward or lifting stroke being given by the high-



COMPOUND STEAM HAMMER.

pressure cylinder, and the downward stroke or working blow by the low-pressure cylinder. The inventor claims that in this way the full advantage of the expansion of the steam is obtained.

As shown in fig. 1, there are two cylinders, one above the other, with two pistons, *a* and *b*, having a piston-rod *c* common to both. The valve *d* is so operated that the steam passes first through the passage *e'* into the small or high-pressure cylinder below the piston *a*, thus raising the hammer ; the valve then establishes communication between the lower and upper cylinders, and steam passes from the high-pressure cylinder through the passages *e'* and *e* to the large cylinder above the piston *b*, where it aids the force of gravity, or weight of the moving parts, in giving the downward blow of the hammer.

The spaces in the cylinders above the small piston and below the large piston are in communication with the atmosphere, in order to prevent resistance to the motion of the hammer.

Fig. 2 shows a method by which this arrangement can be applied to old hammers. The existing cylinder is used as the high-pressure, and a low-pressure cylinder is attached to the frame below, in any convenient manner. In this case, as will be seen, the position of the cylinders is simply reversed, the action being substantially the same.

This arrangement presents some advantages, but it seems as if the gain, in so simple an engine as the steam hammer, was hardly sufficient to compensate for the cost of the additional parts and the greater complexity of the structure.

Electric Railroads in Cities.

(From the *Electrical Engineer.*)

SOME very interesting information has just been issued by the Census Bureau, in a bulletin of which Professor H. C. Adams is the author, giving statistics as to the rapid transit facilities in this country in cities of over 50,000 inhabitants. There are about 50 such cities. We append two tables containing the data :

Year.	Total mileage.	Increase. Miles.	Increase. Per cent.
1880	1,689.54		
1881	1,765.95	76.41	4.52
1882	1,875.10	109.15	6.18
1883	1,941.49	66.39	3.54
1884	2,031.84	90.35	4.65
1885	2,149.66	117.82	5.80
1886	2,289.91	140.25	6.52
1887	2,597.16	307.25	13.42
1888	2,854.94	257.78	9.93
1889	3,150.93	295.99	10.37
Total		1,461.39	86.50

The per cent. of total mileage of 56 principal cities operated by various kinds of motive power was :

	Miles.	Per cent.
Animal power	2,351.10	74.62
Electricity	260.36	8.26
Cable	255.87	8.12
Steam (elevated roads)	61.79	1.96
Steam (surface roads)	221.81	7.04
Total	3,150.93	100.00

The length of line assigned to each of the five leading cities in 1889 was as follows : Philadelphia, 283.47 miles ; Boston, 200.86 ; Chicago, 184.78 ; New York, 177.10 ; Brooklyn, 164.44. The number of miles of track assigned to each city is as follows : New York, 368.62 ; Chicago, 365.50 ; Boston, 329.47 ; Brooklyn, 324.63 ; Philadelphia, 324.21.

The apparent preponderance of Brooklyn and Philadelphia is explained by the fact that in those cities the roads are often single track, going out on one street and returning by another. New York, for example, has 161 miles of double-track road and Philadelphia only 39.

But the main point of interest is the relation between electricity and the other motive powers. The figures above show that in 56 leading cities it is only 8.26 per cent.—a respectable figure, it is true, but still small. On the other hand, the figures for the whole country, as we had occasion to prove recently, are very different. They run thus :

Miles of horse railroad	5,902½
" " electric "	1,753
" " dummy "	556
Cable	441
Total mileage	8,652½
Number of electric roads	164
" " cable "	44

Here, it is seen, electricity is more than 25 per cent. already of the total mileage. It is also more than 25 per cent. of the total number of roads, there being nearly 1,000 in all, but only 807 in independent operation.

THE ESSENTIALS OF MECHANICAL DRAWING.

By M. N. Forney.

(*Continued from page 473.*)

CHAPTER VI.—(*Continued.*)

BELT-PULLEYS.

Figs. 179–181 represent an ordinary belt-pulley used for the transmission of power to or from one shaft to another. The right hand half of fig. 180 is a section on the line *C O* of fig. 179, and the left hand half is a section through the spoke and on the line *D O*. This method is often adopted when it is desirable to show the form of an object at two different places. In the present instance the right-hand side of fig. 180 shows the shape of the rim and hub of the pulley, and the left-hand side shows the form and dimensions of one of the spokes. Fig. 181 is a full-sized transverse section of one of the spokes on the line *A B* of fig. 179. It is often desirable to draw a section of this kind full size when the other views are represented on a smaller scale. The learner is advised to draw the pulley either half or quarter size, and the section of the spoke full size.

At one time it was considered necessary to make the arms or spokes of pulleys of a curved form, so that they could "spring" or "give" if there was any unequal contraction when the casting was cooled. It has been found by experience that this is not essential if the casting is allowed to cool slowly, and now the spokes of such pulleys are nearly always made straight in this country.

As a great many belt-pulleys are used in transmitting and distributing power, it is important in designing them that they should have sufficient strength, and at the same time that no superfluous material should be put into them. This has led to a very careful study of their proportions, rules for which will be given.

In the first place, the rim of a pulley should be somewhat wider than the belt. No great exactness is required, however, in proportioning the rim to the belt; but if the former is made about *one-eighth wider than the belt* it will give good results.

The face of the pulley, on which the belt runs, should be made convex, excepting for shifting belts. The amount of convexity should be about $\frac{1}{4}$ in. per foot of width of pulley face. This would make a pulley with a face 12 in. wide $\frac{1}{2}$ in. larger in diameter in the middle of the face than at its edges. For pulleys with 4 in. faces or less, and those of small diameter, and for high speed, the convexity may be increased.

Unwin, in "The Elements of Machine Design," says the thickness of the rim at its edge should be *equal to three-quarters of the thickness of the belt* + $\frac{5}{1000}$ *the diameter of the pulley.* The following is given as about the average thickness of single belts:

Width of belts, in. ...	2	3	4	6	8	10	12	15
Thickness of belts, in.	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{13}{64}$	$\frac{1}{4}$	$\frac{9}{32}$	$\frac{5}{16}$	$\frac{11}{32}$	$\frac{25}{64}$

The number of arms in a pulley is purely arbitrary, and is generally increased with the diameter. The easiest way to draw the arms is to describe a circle from the center *O* of the pulley, fig. 179 (represented by a dotted circle in this case). Then subdivide the rim into as many equal spaces as there are arms, and draw center lines *D O*, *E O* through the points of division *D E*, and the center *O* of the pulley. From the points of division describe arcs on each side of the center lines, as shown at *E* and *D*. Then draw lines tangent to the arcs and to the dotted circle at the center. These lines will represent the outlines of the spokes.

The following rule has been given by Unwin for calculating the diameters *W* and *w* of the circles at the hub and rim: *Multiply the width of the face and the diameter of the pulley together, and divide by the number of spokes. Take the cube root of the quotient and, for single belt pulleys, multiply it by* 0.6337; *for double belts multiply by* 0.798; *the product will be the diameter W of the circle at the center.* The diameter *w* at the rim should be $\frac{2}{3}$ of *W*. The thickness of the arms should be $\frac{1}{3}$ their width. This may be laid off at *a* and *b* fig. 180, *a* being equal to $\frac{1}{3}$ *w* and *b* equal to $\frac{1}{3}$ *W*.

A rib *r r* is cast on the inside of the rim between the spokes, to strengthen the rim. This rib is of the same thickness as the spokes, and its projection *c* from the rim is also equal to their thickness. The radii *d* and *e*, fig. 179 of the curves which join the spokes to the rim and to each other are entirely arbitrary, and may be left to the judgment and taste of the draftsman. After locating the center of one of each of these curves, arcs of circles should be drawn from the center *O* through each point, where a center must be located. This facilitates the finding of the exact position of the centers, which will be in the arcs thus drawn.

BELT PULLEY.
Scale 1½ in.=1 ft.

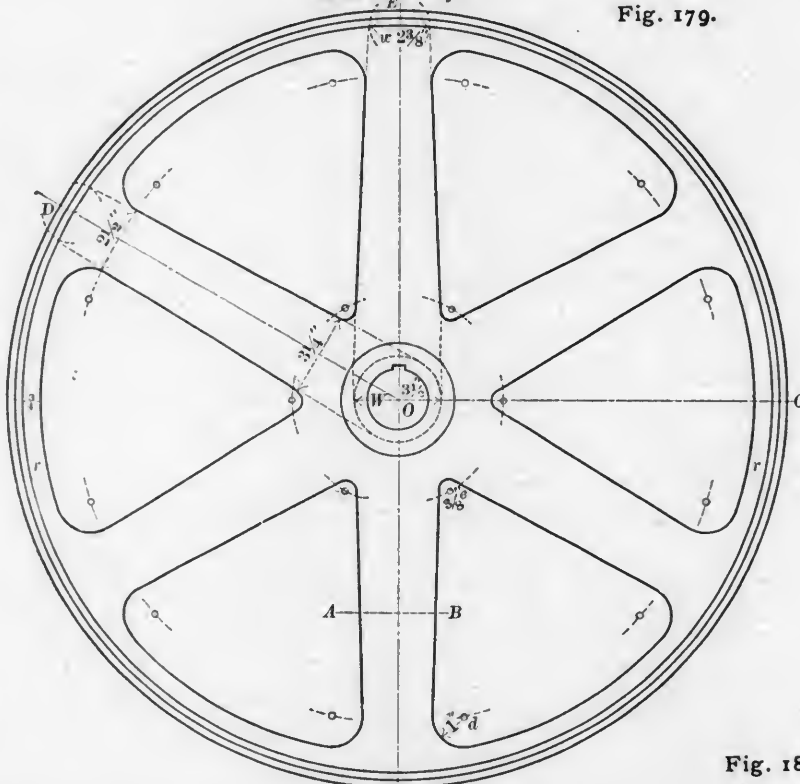


Fig. 179.

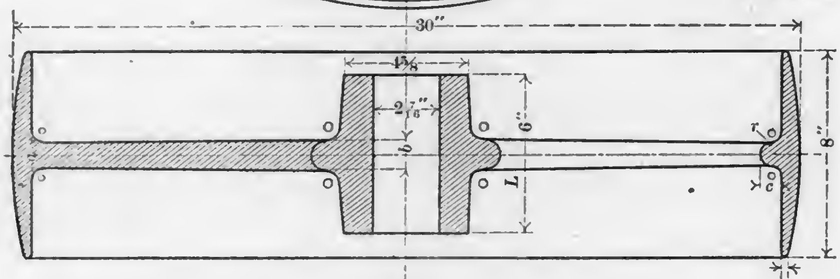


Fig. 180.

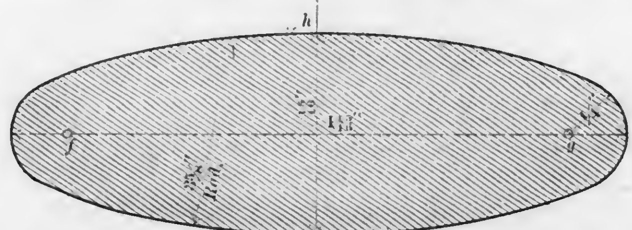


Fig. 181.

FULL SIZE SECTION OF SPOKE ON LINE A.B.

The length L of the hub, fig. 180, is usually made three-quarters the width of the face, and the thickness of the metal outside the shaft may be calculated as follows: *Multiply the diameter of the pulley by the width of its face in inches. One-sixth of the cube root of the product will be the thickness of the metal at the faces of the hub.*

Fig. 182.
SADDLE KEY.

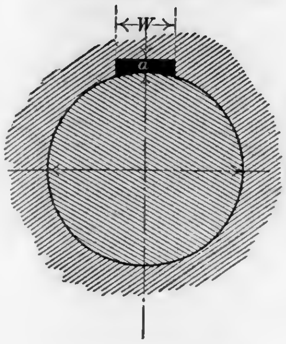


Fig. 183.
KEY ON FLAT.

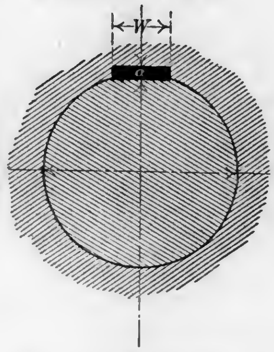
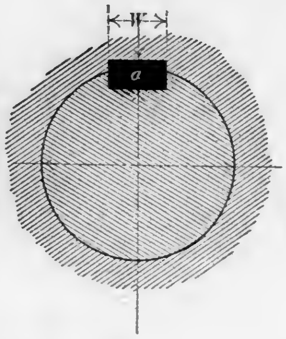
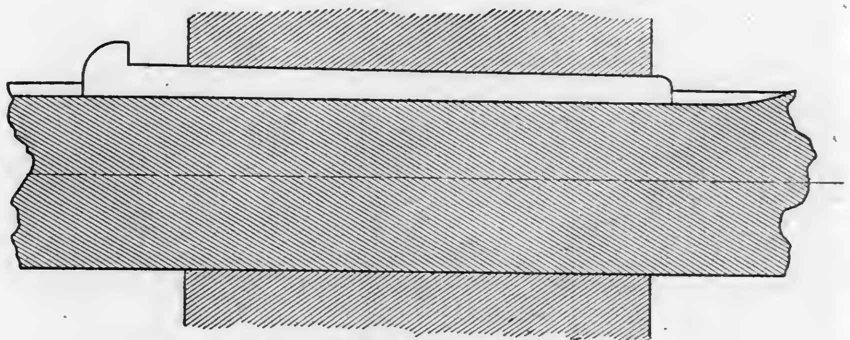


Fig. 184.
SUNK KEY.





SECTION OF SHAFT AND HUB SHOWING KEY.
Scale ⅜ in. = 1 in.
Fig. 185.

The form of the section of the spoke, fig. 181, may be drawn with dividers from centers f and g, and other centers on the vertical center line $h\ i$, extended above and below the figure. A more elegant form for the outline of the section of the spoke is a true ellipse, the method of drawing which will be described in another chapter.

KEYS.*

Wheels, pulleys, couplings, cranks, etc., are prevented from turning round the shaft by means of flat wedge-shaped pieces called keys, which are driven between the shaft and the wheel in a groove or grooves cut in the shaft or hub, or both. Figs. 182–184 represent sections of shafts and of part of the hubs on the shaft. The groove d in the shaft, fig. 184, is called a *key-way;* those in the hubs, $d\ d\ d$, figs. 182–184, are called *key-seats.* The width W, figs. 182–184 of the keys is the same throughout their length, but their thickness tapers or decreases gradually toward the end at the rate of from about 1 in 24 to 1 in 96.

Keys are of three kinds—viz., the "saddle" key, fig. 182, the "key with flat on shaft," fig. 183, and the "sunk" key, figs. 184 and 185.

The "saddle" or hollow key, fig. 182, is made with its under face concave to fit the surface of the shaft. It is driven into a groove or key-way cut in the hub, and when driven up tightly causes the wheel to grip the shaft. It is only used when the power to be transmitted is small, as in belt pulleys. The advantage of the saddle key is that the pulley can be removed along the shaft and readily secured in any position.

The "key on flat," fig. 183, differs from the saddle key in requiring a flat bed to be made for it on the shaft. It is much more common, and a somewhat stronger arrangement than the saddle key.

The "sunk key," fig. 184, is the most trustworthy form, and is the one adopted for all purposes where the power to be transmitted is at all considerable. For this key a groove is cut in the shaft, in which the key is firmly embedded, the remainder of the key fitting into a corresponding recess in the hub, as shown in the figure.

The width W of keys is made $= \frac{1}{4}$ the diameter of the shaft $+ \frac{1}{8}$ in. The depth d in the middle of the saddle key and key on flat $= \frac{1}{4}$ the width. The depth d of the sunk key $= \frac{1}{2}$ its width.

Fig. 185 is a section of a shaft and hub showing a side view of a key. If the end E of the key is inaccessible to drive it out of the key-seat a gib-head G is put on the opposite end, so that the key can be removed by driving a wedge between its head and the hub.

Shafting is usually made of round bar iron of the regular sizes, which is reduced in diameter about $\frac{1}{16}$ in. by turning. For this reason standard sizes of shafting are of the following diameters: $1\frac{7}{16}$, $1\frac{11}{16}$, $1\frac{15}{16}$, $2\frac{3}{16}$, $2\frac{7}{16}$, $2\frac{11}{16}$, $2\frac{15}{16}$, $3\frac{3}{16}$, $3\frac{7}{16}$, $3\frac{11}{16}$, $3\frac{15}{16}$, $4\frac{3}{16}$, $4\frac{7}{16}$, $4\frac{15}{16}$, $5\frac{7}{16}$, $5\frac{15}{16}$, $6\frac{7}{16}$ and $6\frac{15}{16}$ in.

The student is advised to calculate the proportions and draw keys full size for shafts $1\frac{15}{16}$ and $4\frac{3}{16}$ in. diameter.

CHAPTER VII.

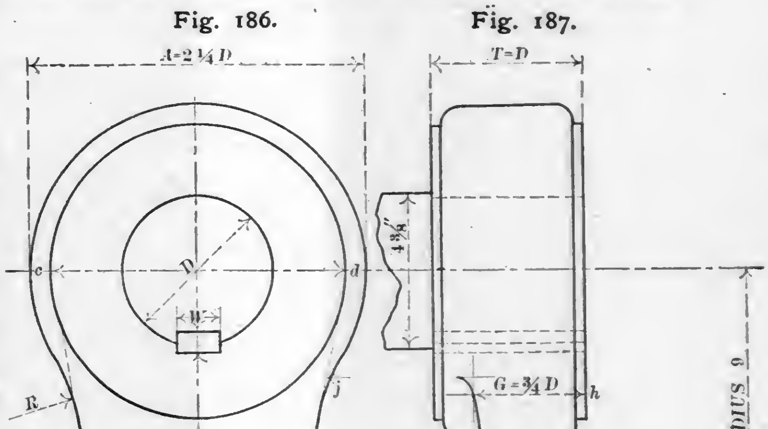
THE STEAM-ENGINE.

One of the principal organs of a steam-engine is the crank, as it is by means of it that the reciprocating motion of the piston is converted into the rotary motion of the shaft. In this country the cranks of stationary engines are generally made of cast iron. Figs. 186 and 187 are front and side views of such a crank for an engine* with a 10-in. cylinder and 18-in. stroke.

Such cranks should be proportioned to the diameter of the shaft, which is represented by D in the engravings. The *radius* of the crank is the distance from the center of the shaft D to the center C of the crank-pin, and is equal to half the stroke of the piston. The *throw* of the crank is equal to twice its radius, and to the stroke of the piston.

The thickness T of the boss on the shaft is equal to D, the diameter of the shaft. The diameter A of this boss is equal to $2\frac{1}{4}$ times D. No exact rule can be given for the diameters d of crank-pins, as practice varies within wide limits. The general

Fig. 186. Fig. 187.



CRANK.
Scale 2 in. = 1 ft.

tendency with all classes of engines is to increase the diameters of the pins. In the present instance, d of the pin C is $2\frac{1}{2}$ in. diameter, and its journal is the same length. *The diameter a of*

* The following description of keys is taken from Ripper's "Machine Drawing and Design."

* This and the following illustrations in this chapter are taken from drawings of a stationary engine built by the Fishkill Landing Machine Company at Fishkill on Hudson, N. Y.

crank-pin boss is made $2\frac{1}{4}$ *times d that of the crank-pin, and the thickness t of the boss is* $1\frac{1}{2}$ *d.*

The outline of the crank-arm may be drawn by laying off from the center of the shaft on a horizontal center line passing through it a distance *c d* equal to twice the diameter of the shaft, and from the center of the crank-pin laying off a similar distance, *e f* = to twice the diameter of the crank-pin, and drawing lines *c e* and *d f* through the points thus laid down. Curves should be drawn, with radii *R* and *r* equal to the radii of the two bosses, tangent to the outlines of the bosses and the lines *c e* and *d f*.

The thickness G of the crank-arm where it joins the large boss is equal to $\frac{3}{4}$ *D, and the thickness g is equal to* $\frac{3}{4}$ *t.* To draw the outline *G g*, lay off the thickness from *h* and *i*, and draw vertical lines, as shown at *G* and *g*. Then with the T-square draw horizontal lines from *j* and *k* of fig. 186, extended to *G* and *g*. With a radius somewhat greater than that of the curve which joins the crank-arm to the hubs, draw curves at *G* and *g* tangent to the horizontal and vertical lines. These will represent approximately the outline of the back side of the crank-arm, and is sufficiently correct for all practical purposes.

ECCENTRIC.
Scale ¼ in. = 1 in.

Fig. 189.

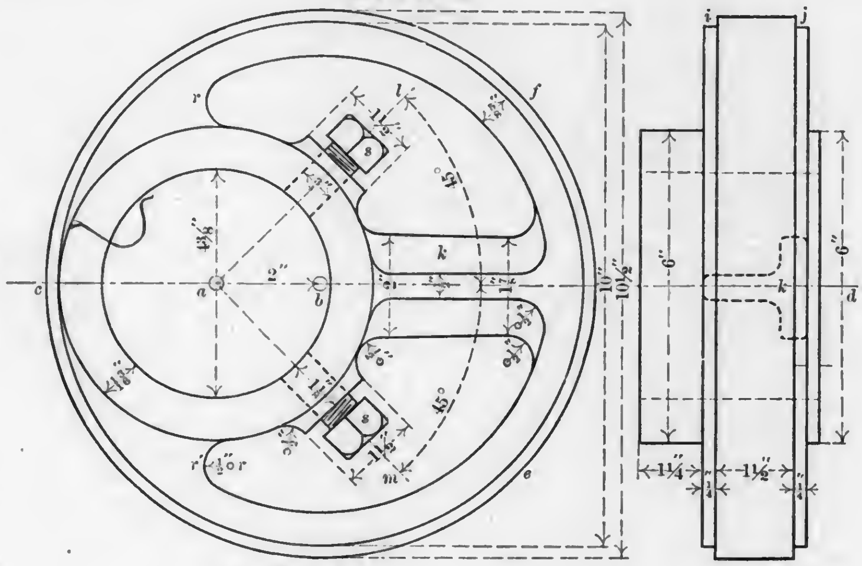
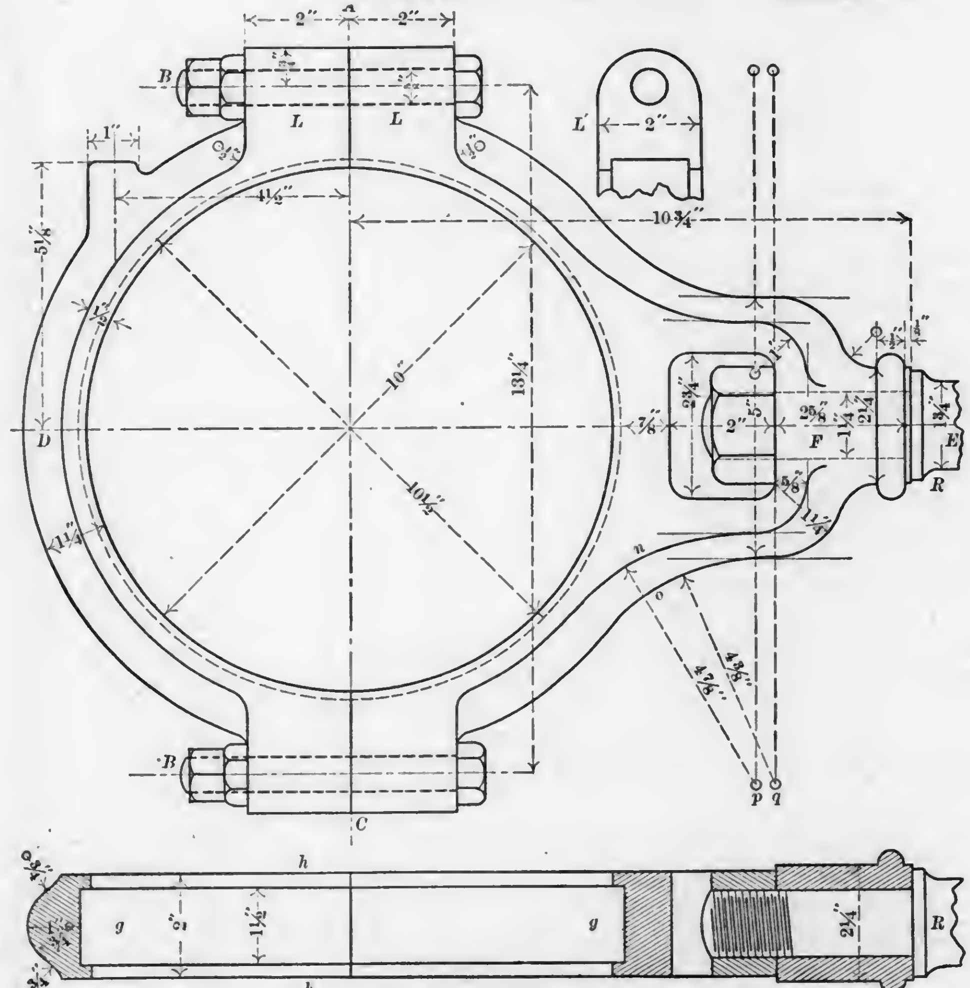


Fig. 190.

Fig. 191.

Fig. 192.



ECCENTRIC STRAP.
Scale ¼ in. = 1 in.

The diameter *D* of the shaft inside of the hub of the crank is $4\frac{1}{2}$ in. Just back of the crank it is $4\frac{5}{8}$ in., a shoulder being turned on it to limit the movement of the crank. The crank-pin where it fits into its hub is made either straight or slightly tapered, and is driven or pressed into the boss and riveted on the back side of it.

The key in the shaft is proportioned in the same way as the

keys for pulleys—that is, *its width $W = \frac{1}{4}$ the diameter D of the shaft $+ \frac{1}{8}$ in., and its thickness is equal to one-half its width.*

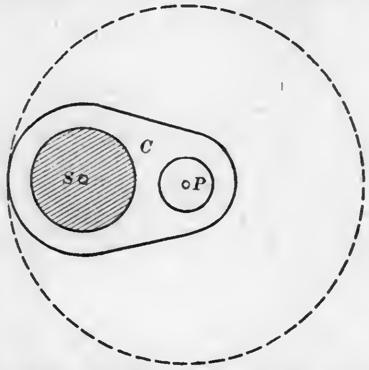
The student should draw a crank half size for a shaft $4\frac{1}{4}$ diameter, and calculate its proportions from the rules given, and mark all its dimensions on the drawing.

ECCENTRICS.

The chief use of the eccentric is in the steam-engine, where it is employed to work the valves. It has been defined as a crank in which the crank-pin is large enough to embrace the crank-shaft. Thus, let C, fig. 188, be a small crank, S the shaft, and P the crank-pin. If we simply increase the diameter of the pin to that of the dotted circle, so as to embrace the shaft, the crank becomes an eccentric.

The advantage which an eccentric has over a crank is that an eccentric can be put on a shaft in any position, without altering

Fig. 188.



the form of the shaft, whereas, if a crank is used, the form of the shaft must be changed, or its continuity must be broken to form the crank.

The portion of the eccentric which corresponds to the crank-pin, and which embraces the shaft, is called the *sheave*. This is generally made of cast iron. Figs. 189 and 190 represent a side and front view of an eccentric for the engine described in the beginning of this chapter. Such eccentrics are usually made of cast iron. They are drawn from two centers, a and b—a is the center of the shaft and b that of the sheave.

The distance from the center a of the shaft to b, that of the sheave, is called the *radius* of the eccentric. The *throw* is twice the radius.

A ring of metal called an eccentric-strap, represented by figs. 191 and 192, is made to fit the outside of the eccentric accurately, and is connected to the valve gear by a rod, called an *eccentric-rod*, one end of which is shown at E, fig. 191. By this means the motion of the eccentric is transmitted to the valve.

The strap in nearly all cases is divided into two halves, their line of separation, $A\ C$, being at right angles to the center-line $D\ E$ of the eccentric-rod. The two halves are held together by bolts $B\ B$. The straps are also made of cast iron.

The rod R is fastened to one part of the strap by a nut, as shown in the figures, or in some cases by bolts.

The hub of the eccentric is bored out to fit the shaft, and is fastened to it by set screws $s\ s$, fig. 189.

The student should draw the eccentric and strap either full or half size. In doing this he should first draw a horizontal center-line $c\ d$. On this line he should lay down the center a of the shaft and b of the sheave, at a distance apart equal to the radius—in this case 2 in. From the center a he can then draw a circle whose diameter is equal to that of the shaft, or $4\frac{3}{8}$ in. From b the circles representing the circumference or periphery, $c\ e\ f$, of the eccentric, can be drawn. From fig. 190 it will be seen that the central part $i\ j$ of the periphery is made larger in diameter than the outer edges. This larger portion fits into a groove in the straps shown at $g\ g$, fig. 192, which is a sectional plan drawn on the line $D\ E$ of fig. 191. The strap has shoulders, $h\ h$, which fit the portions of the periphery of the eccentric which are shown at i and j, fig. 190, and are of smaller diameter than the central part. The object of the shoulders is to hold the eccentric straps in their place on the eccentric. Sometimes the central part of the eccentric is made smallest in diameter, but the method shown in the engraving is considered the best, because it gives the whole width of the eccentric for bearing surface, and protects the latter more perfectly from dust and dirt, and the groove $g\ g$, fig. 190, in the straps holds oil better than a groove in the eccentric will.

The eccentric has an arm k, fig. 189, the section of which, in this instance, is made of **T** form, as shown by the dotted lines in fig. 190. The rim is made $\frac{5}{8}$ in. thick, as shown at f, fig. 189. After drawing the arm k and the circle representing the inside of the rim, they should be joined together and to the hub of the eccentric by arcs of circles, or *fillets*, as they are called. In the engraving these are all of $\frac{1}{2}$ in. radius.

The set-screws $s\ s$ are both located on center lines $a\ l$ and $a\ m$, which are drawn at angles of 45 degrees to the center line $c\ d$. Bosses or projections are made on the hub, so as to give a greater length for the bearing of the threads of the screw. These bosses are not shown in fig. 190, as their delineation involves principles of projection which have not yet been explained, but will be taken up in another chapter.

The inside and the outside of the eccentric straps, figs. 191 and 192, are drawn from the same center. The centers of the bolts $B\ B$ are located $13\frac{1}{4}$ in. apart. Half this distance should be laid off on each side of the center line $D\ E$, and the bolts should be drawn on center lines passing through the points thus laid down. Lugs or projections $L\ L$ are cast on each of the straps, to receive the bolts $B\ B$. An end view of one of these lugs is shown at L'.

The method of drawing the boss F to receive the eccentric-rod hardly needs explanation. The positions of the vertical lines, which define its limits, are indicated by the figures, and should be laid down on $D\ E$, and the horizontal lines should be laid off on each side of $D\ E$. After the straight horizontal lines are drawn, their intersections with the vertical lines should be joined by arcs of circles, as shown. The curves n and o are drawn from centers p and q, which are located on perpendicular lines drawn from $D\ E$, as shown. Owing to the small size of the engravings, they *appear* complicated. This appearance will vanish when the student lays them down to a larger scale and has more room on the paper.

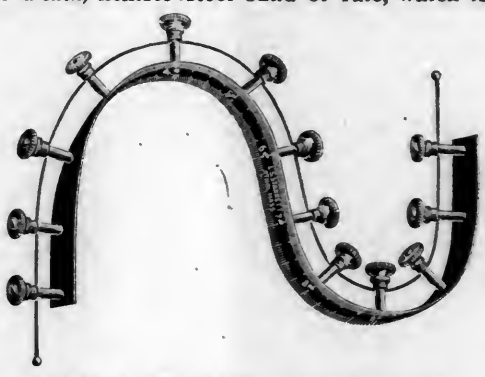
In making these drawings, he should remember that every line and curve which is drawn must be reproduced on the patterns. For this reason, the radii and centers of all curves should be indicated. In cases where there are a number of curves which are alike, it is sufficient to indicate the center and radius of one of them.

A draftsman cannot be too particular, either, in giving all the dimensions on a drawing, but he should be especially careful to give the important ones. It is not an unusual occurrence to find that all the minor dimensions have been given, and one or more of those which are most essential omitted. The caution will be repeated here that after the drawing is finished and the dimensions have been marked on it, the person who made it should go all over it with his scale, to see whether the dimensions and the measurement agree with each other. Serious errors can often be detected in this way.

(TO BE CONTINUED.)

Flexible Curve-Rule.

THE engraving herewith represents an ingenious rule for drawing irregular curves. It can be adjusted to any desired form and is the invention of Mr. E. T. Bradley. These rules are manufactured by Blake & Bradley, of Swanton, Vt. They consist of a thin, flexible steel band or rule, which is divided



BLAKE & BRADLEY'S CURVED RULE.

into a scale of inches. To this studs are rigidly attached by riveting them to the band. Each of the studs has a hole near its upper end through which a wire passes loosely. It also has a set-screw on its upper end with a knurled head, and the end of the screw bears on the wire. When the screws are loose the wire can slide easily in the holes, and the steel band is then entirely flexible, and can be bent to conform to any curve. When the screws are tightened the wire braces or stiffens the band so that it becomes rigid and holds it in any desired position, and it can then be used as a ruler. Its uses will be obvious to any experienced draftsman who has been compelled to whittle out templates for drawing curves, which could not be drawn with any of these harassing "hard rubber curves" which are sold by instrument makers. The flexible curve seems to

be a very valuable instrument for architects, designers, draftsmen, and pattern makers, especially those engaged in marine work or in drawing or measuring various irregular curves of any kind. One of its uses was suggested in some experiments made some time ago to determine the proper shape for a car-seat back. To do this a box similar to a large arm-chair was constructed, and several different persons' forms were moulded in it in sand. A pasteboard template was then cut to fit the form thus left in the sand. The instrument herein described could have been adjusted to the impression left in the sand and could have been quickly and easily transferred or reproduced on paper. For carriage makers or car-builders, or, in fact, designers generally it will be very useful. The expression is not very new or original, but it has the merit of being true that this rule "fills a long-felt want."

The rules are made of two different qualities, one for work when great precision is needed, the other for coarser uses. Three sizes of each quality are also made. The rules of the first quality are 12, 18, and 24 in. long, those of the second 24, 36, and 48 in.

Recent Patents.

LA PAGE'S COMPOUND LOCOMOTIVE.

This invention, which is covered by patent No. 431,899, issued to Richard Herbert La Page, of Westminster, England, is shown in figs. 1 and 2; it refers chiefly to the arrangement of the cylinders, in which two low-pressure cylinders of smaller

FIG. 1.

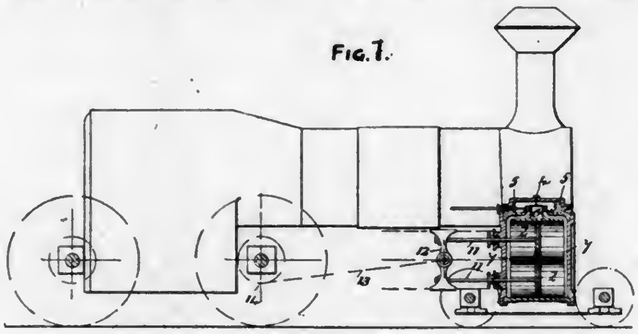
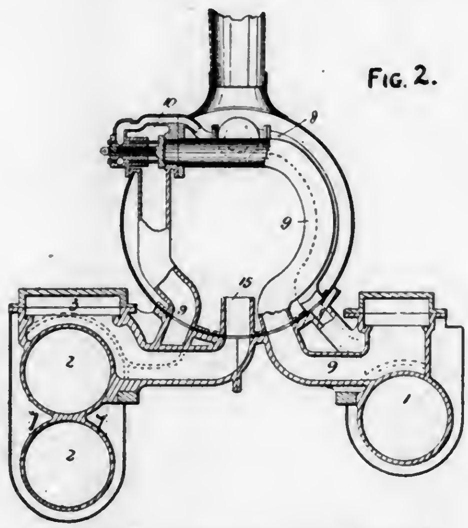


FIG. 2.



LA PAGE'S COMPOUND LOCOMOTIVE.

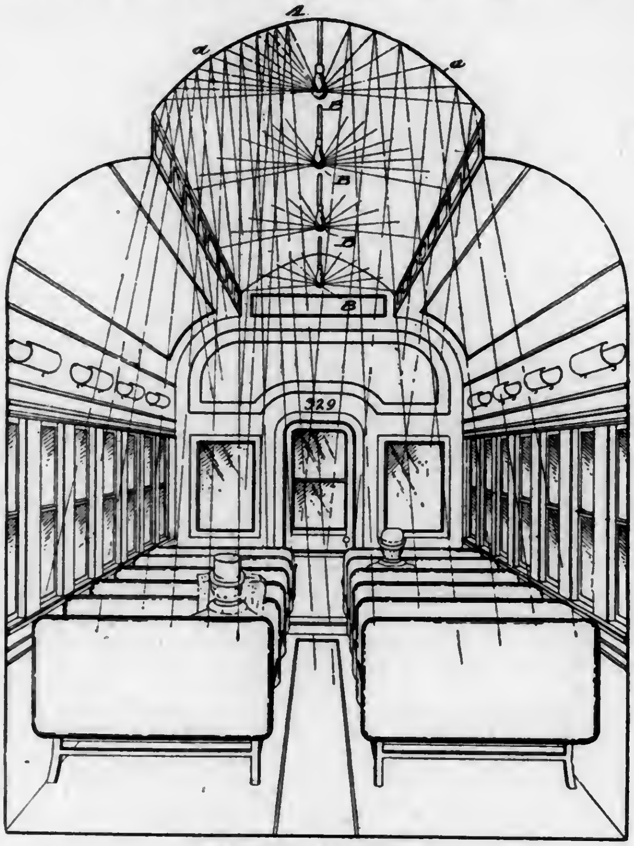
size are substituted for one large one, in order to obviate the objections made to the use of a very large cylinder.

Fig. 1 is an elevation of a locomotive and fig. 2 a cross-section, on a larger scale. In these 1 is the high pressure cylinder; 2 2 the low-pressure cylinders; 3 the steam-chest; 4 the valve; 5 6 the ports; 7 the connecting passages between the low-pressure cylinders; 8 the steam-pipe to the high-pressure cylinder; 9 the connecting-pipe which carries steam from the high-pressure to the low-pressure cylinder; 15 the blast-pipe or exhaust common to both low-pressure cylinders.

The connecting steam-pipe 9 may be fitted with a valve-case 10, containing combined intercepting and starting valves constructed to operate in an automatic manner. The pistons of the two low-pressure cylinders are connected by their rods 11 to one slide-block or cross-head 12, that is guided in the ordinary manner and coupled to one end of a connecting-rod 13, the other end of which is coupled to the crank-pin 14 of the driving-shaft in the usual manner.

KOYL'S CAR-ROOF.

The accompanying illustration shows a form of car-roof which is covered by Patent No. 436,361, issued to Charles Herschel Koyl, of Easton, Pa. The invention is designed to improve the lighting of railroad cars and similar structures.



KOYL'S CAR-ROOF.

The inventor claims that in cars, as usually built, the lamps are placed in the center and a little below the ceiling, and much of the light is thus lost. To remedy this he proposes to make the car-roof, or at least its interior face, parabolic in cross section, the object being to reflect downward upon the passengers the light which would otherwise be lost. With this shape he combines the placing of the lamps or other lights at a focal distance from the ceiling; that is to say, in the lines of the foci of the parabolic curves which give the contour to the roof. The illustration shows a cross-section of a car in which the curvature is confined to the interior of the dome or raised central portion *A* of the car-roof. The interior surface of this portion of the roof is parabolic in cross-section, as shown by the curves *a a*, but with no longitudinal curvature. In the line of the foci of the parabolic curves are placed at proper intervals the incandescent electric lights *B*. With this arrangement the upward rays from the lamps, which would otherwise be lost in the ceiling, are reflected downward in nearly parallel course, as shown by the dotted lines, in such a way as to aid the direct downward rays, and to about double the available light.

Manufactures.

Marine Engineering.

The engine which the Cleveland Ship Building Company will build, together with boilers and wheels for the side-wheel steamer, to be built this winter by the Craig Ship Building Company, of Toledo, will be a novelty in this section of the country. The engine is an inclined triple-expansion, having cylinders 26, 42 and 66 in. diameter by 6 ft. stroke, directly connected to three double cranks, set at an angle of 120° to each other. It will be provided with steam reversing engine and independent air pumps, and will turn feathering side wheels 19 ft in diameter at a rate of 40 revolutions a minute. The engine will be supplied with steam by two boilers, of the gunboat type, 11 ft. diameter and 21 ft. long, with three furnaces each, and will be allowed 160 lbs. working pressure. This

arrangement does away with the heavy cumbersome gallows frame, walking beam, and heavy connecting rod, and will secure an even, steady turning of the wheels, thereby obviating the jerky motion of the ordinary beam engine. It is expected by the builders to drive the proposed boat no slower than the fastest, to say the least. The company also contracted recently for the construction of two immense tanks 6½ ft. inside diameter and 104 ft. long each, made of ¾-in. steel plate. These are to be delivered in New York in about 90 days.—*Cleveland Marine Review.*

THE Risdon Iron & Locomotive Works, San Francisco, have recently completed an overhauling of the Pacific Mail steamer *City of Sydney*. The work included general repairs of the engines and the building of six new boilers, each 13 ft. in diameter and 10 ft. 6 in. in length, each boiler having three corrugated furnaces 36½ in. in diameter and 7 ft. 6 in. long. These boilers are built for a working pressure of 80 lbs.

THE arrangements have been completed for the transfer of the Roach Yards at Chester, Pa., to the Roach Ship Building & Engineering Company, Limited. This is an English concern, although a part of the capital is owned in this country, and purchases the yards at Chester with the other property controlled by the Company. Of the eleven directors, four reside in this country, including John B. Roach, the present head of the concern, and George E. Weed, President of the Morgan Iron Works, in New York.

Locomotives.

THE Brooks Locomotive Works, Dunkirk, N. Y., have orders for 60 locomotives for the Atchison, Topeka & Santa Fé Railroad.

THE traffic through the St. Clair tunnel on the Grand Trunk Road will be worked by locomotives built especially for that service. These are tank locomotives of the Decapod type, and are now under construction at the Baldwin Locomotive Works in Philadelphia. They have boilers 74 in. in diameter, with 280 tubes 2¼ in. in diameter and 13 ft. 6 in. long. The fireboxes are 11 ft. long and 3½ ft. wide. The working pressure will be 160 lbs. The cylinders are 22 in. in diameter and 28 in. stroke; there are five pairs of driving wheels 49 in. in diameter. One of these engines will weigh in working order, including 1,800 galls. of water in the tank, about 90 tons.

Cars.

THE Lehigh Car & Manufacturing Company, Stemton, Pa., has just completed 400 box cars for the Charleston, Sumter & Northern, and is building 100 freight cars for the Lehigh & Hudson River Railroad.

THE Oregon Equipment Company is building a number of freight cars for different roads at its shops in Seattle, Wash.

THE Jackson & Sharp Company, Wilmington, Del., has recently built a number of passenger cars for export, some of them going to France and some to Spain.

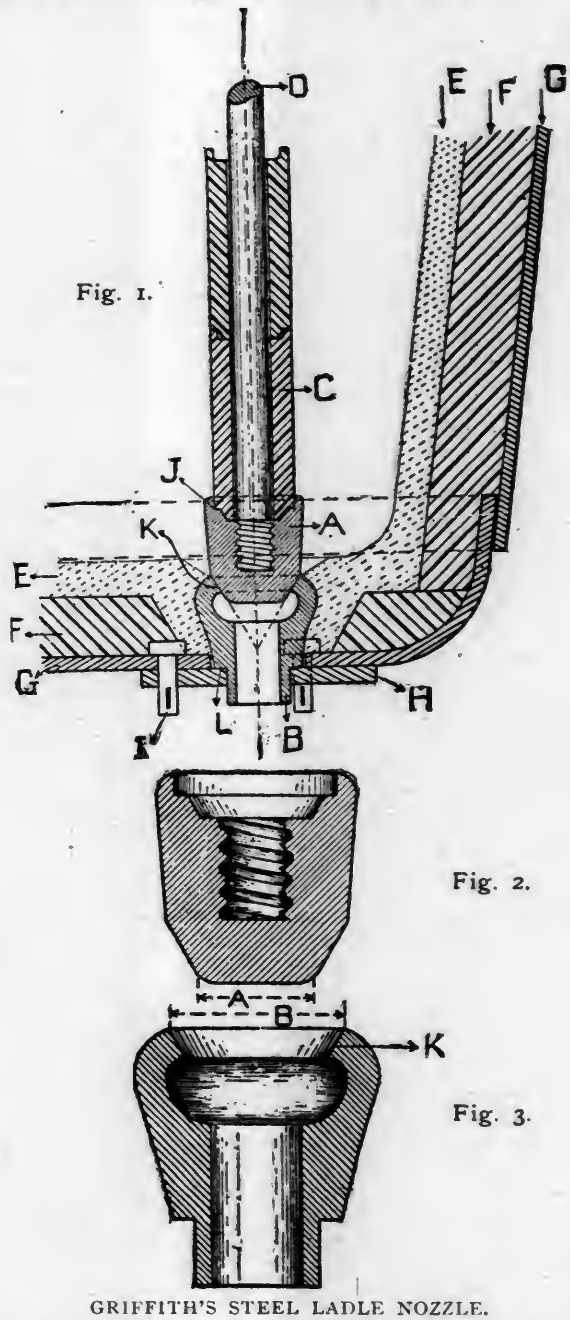
THE Westinghouse Air-Brake Company has completed its removal to the new shops in Wilmerding, Pa., where the general offices are also located, although a city office will be maintained in Pittsburgh. The old shops in Allegheny City are now occupied by the Fuel Gas & Manufacturing Company, which is also a Westinghouse concern.

Griffith's Steel Ladle.

THE accompanying illustration shows a stopper and nozzle for open-hearth and Bessemer steel ladles. Fig. 1 is a section through a portion of the ladle; fig. 2 is an enlarged section of the stopper, and fig. 3 of the nozzle.

In fig. 1, *G* is the shell of the ladle; *F* the permanent lining of fire-brick, which is allowed to remain in the ladle an indefinite length of time; *E* is the temporary lining, composed of loam or of fire-clay and sand, which seldom lasts more than one week; *D* is the stopper-rod, screwed into the stopper *A*, and covered with a fire-clay sleeve *C*. The stopper *A* is shown on a larger scale in fig. 2. The nozzle *B*—shown on a larger scale in fig. 3—passes through the shell of the ladle, the shoulder *L* resting on the nozzle-plate *H*, which is fastened to the ladle by three cotter-bolts *I*.

The inventor's directions for using this device are as follows: "In preparing a stopper, if the rod and gooseneck are welded together in one piece, first slip over the rod a wrought-iron washer with an inside diameter of 1⅜ in., or ⅛ in. larger than the diameter of the rod, then the requisite number of stopper-rod sleeves, after which gently but firmly screw the stopper on to the end of the rod. After this has been done stand the rod on end and carefully allow the sleeves to slip down into position, placing a small quantity of moderately stiff clay between the joints *J* to make them perfectly secure. After they are all in position, slip the washer down upon the top sleeve and secure it by driving three eightpenny nails between it and the rod, placing them 120° apart. A straight rod that is secured to the gooseneck by jamb-nuts can be made up in the same manner, or it can be made up independent of the gooseneck and



GRIFFITH'S STEEL LADLE NOZZLE.

secured to it just prior to using. To insure success the ladleman must not use too much force in screwing the stoppers fast or he will strip the threads out from them. He must also carefully inspect the screws after they have been used, preferably by screwing a standard nut over them to be sure that the thread is not distorted or lumpy. The thread on the rod should be a trifle smaller than that in the stopper.

"In lining the ladle keep the fire-brick lining 5 or 6 in. away from the nozzle, and fill the space thus formed with the loam lining, chamfering it off around the nozzle as shown in sketch. This will enable the ladleman to renew the nozzle much more rapidly than if the fire-brick lining is run up close to the nozzle.

"In open-hearth practice we do not advise the use of either the

stopper or nozzle for more than one heat, and although it can be successfully accomplished, it is not an economy in the end."

The advantages claimed for this device are that it prevents leakage, and will not burn off while in use.

A New Sound Steamer.

THE new steamboat *Plymouth*, built for the Old Colony Steamboat Company by the W. & A. Fletcher Company, of New York, has had her preliminary trial trip. The *Plymouth*, which is to run in the Fall River Line on Long Island Sound with the *Puritan* and the *Pilgrim*, has the following dimensions: Length over all, 366 ft.; length on water line, 351 ft. 8 in.; breadth over guards, 86 ft.; breadth of hull, 50 ft.; depth at lowest point of sheer, 21 ft.; draft of water light, 11 ft.; distance from keel to topmast head, 119 ft.; distance from keel to dome deck, 55 ft. 3 in.; distance from keel to top of house on dome deck, 59 ft. 4 in. She will be propelled by feathering wheels 30 ft. in diameter, each wheel having 12 steel buckets 13 ft. 3 in. long and 4 ft. wide. These wheels are driven by an inclined triple-expansion engine having a high-pressure cylinder 47 in., intermediate cylinder 75 in. and two low-pressure cylinders each 81½ in. in diameter, all having 8 ft. 3 in. stroke. Steam is furnished by eight steel boilers of the Scotch type, 11 ft. 4 in. in diameter and 13 ft. 1 in. long, built to carry 160 lbs. working pressure. She will have 250 state-rooms, and will be very handsomely fitted up.

OBITUARY.

PROFESSOR ARTHUR J. STACE, for some time past Professor of Civil Engineering in the University of Notre Dame, Ind., died September 25, after a brief illness. He was a man of active and acute intellect, and as a teacher commanded close attention from his students. He was also an author, and several of his books have attracted much attention. He was one of the representatives of the United States at the Paris Exposition in 1889.

THOMAS FRANKLIN HOXSEY, who died in Paterson, N. J., October 14, aged 49 years, was born in that city and educated as a civil engineer. He was employed in that capacity for some time, and afterward as contractor built a considerable section of the New Jersey Midland, now the New York, Susquehanna & Western, the works of the Passaic Water Company and other undertakings. For some time past he had been Manager for the syndicate which has been securing control of water rights in Northern New Jersey.

FREDERICK BILLINGS, who died in Woodstock, Vt., September 30, was a lawyer by profession, but of recent years had been known principally for his interest in railroad affairs. He was born in Vermont in 1823, and was brought up in that State, but when still a young man went to California, where he was very successful, and amassed a large fortune. He retired from the practice of law in 1866 and returned to Vermont to live, spending much of his time, however, in New York. He was largely interested in the Northern Pacific Railroad, and was at the head of the reorganization of that road after the failure in 1873. He was President for several years and a director until very recently. He was also interested in a number of other railroad enterprises. He was one of the original promoters of the Nicaragua Interoceanic Canal, was one of the incorporators of the Company, and at the time of his death was Chairman of the Executive Committee. Mr. Billings was well known as a liberal and public-spirited man, who contributed freely both his time and means to religious and other organizations.

RICHARD N. ALLEN.—The news of the sudden death of Richard N. Allen, the President of the Allen Paper Car Wheel Company, has been the cause of grief and sadness to a large circle of his friends, who are to be found in all parts of the country. He died of heart disease at his home in Cleveland on October 7. His life was a typical example of the kind of career which is, or was, open to all American youths. He was born near Springfield, Mass., in 1827. He began as a fireman of a locomotive on the Connecticut River Railroad at the age of 18, and when he was 19 he was promoted to the position of engineer.

In 1852 Mr. Allen moved to Cleveland, O., and ran a locomotive on the Cleveland & Toledo Railroad, but was soon after promoted to the position of Master Mechanic of the northern division of the road with headquarters at Sandusky. At Cleveland he was riding in a locomotive the boiler of which exploded and killed the engineer and fireman, and seriously injured him, so that he was carried home on a stretcher and given up for dead. He recovered, however, but bore the marks of his injuries all his life.

He moved south soon after and became Master Mechanic of the New Orleans, Jackson & Great Northern Railroad. During the war his connection with that road was broken up, and he finally returned to Cleveland. He then invented a car journal-box and a barrel to contain oil, and afterward tried his fortunes in the oil regions of Pennsylvania and sank several wells, with what success is not known.

After this he was induced to take an interest in a straw-board mill at Pittsford, Vt., which was not profitable, and the whole enterprise finally fell into Mr. Allen's hands. He then conceived the idea of making the centers of car-wheels of compressed paper or straw-board, and finally made a model of such a wheel. The chief difficulty consisted in holding the tire on the wheel, and after this was overcome in inducing any railroad companies to try the wheels, and thus get them into practical use. Finally the officers of the Rutland & Burlington Railroad were induced to try a set under a light car. After a time he went to Hudson, N. Y., and engaged in the manufacture of the wheels there. He still had difficulty in holding the tires to the wheels, and like most other new inventions it was some years before it was perfected to the inventor's satisfaction. He spent some time at the Krupp works studying the problem. He finally induced Mr. George M. Pullman to interest himself in the wheel, and to adopt it for the sleeping cars of the Pullman Company. Aided with the capital and enterprise of Mr. Pullman extensive works for the manufacture of the wheels were established at Hudson, N. Y., and at Pullman, Ill. Many thousands of these wheels are in use, which fact is testimony of the success of Mr. Allen's invention. Recently he had been engaged in improving his paper wheels and adapting them for street-car service.

Mr. Allen was of a singularly gentle and kindly disposition, which made him a deserved favorite among the people with whom he came in contact, and he had the reputation among those who had opportunities of judging of being scrupulously just and fair in his transactions with others—a reputation difficult to maintain by any one engaged in the tortuous ways in which business with some railroad companies and officers must be conducted. Mr. Allen's death is an irreparable loss to his many friends and acquaintances who were encouraged by his cheerful ways and character, and gladdened by his friendship and good-will.

PERSONALS.

HENRY C. ALLEN has been appointed City Engineer of Syracuse, N. Y. He has been Deputy City Engineer for some time.

GEORGE D. HARRIS, late on the Richmond & Danville Railroad, is now Master Mechanic of the Georgia Southern & Florida Railroad.

A. RICCIO, late Chief Engineer of the Georgia Pacific, is now Chief Engineer of Construction of the Georgia, Carolina & Northern Railroad.

T. M. T. MCKENNAN is now Chief Engineer in charge of location and construction of the new Tennessee River, Ashville & Coosa Railroad in Alabama.

THOMAS L. CHAPMAN is now Mechanical Engineer of the Iron Car & Construction Company, of New York. He was recently with the Central Railroad of Georgia.

H. P. LATTA has been appointed Master Mechanic of the Chicago & Erie Railroad, with office at Huntington, Ind. He was formerly on the Lake Shore road.

CHARLES B. COUCH, late Superintendent, has been appointed Purchasing Agent of the Lake Shore & Michigan Southern Railway, succeeding L. C. HIGGINS, deceased.

L. C. NOBLE, General Master Mechanic of the Houston & Texas Central Railroad, will retire from that position to engage in the business of manufacturing and introducing the nut-lock which he has invented and patented.

JAMES F. GODDARD has been appointed to the position of Commissioner of the Trunk Lines Association, which has been vacant since the resignation of Mr. Albert Fink. Mr. Goddard has had an extended experience as a traffic manager.

MAJOR H. WADSWORTH CLARKE has resigned his position as City Engineer of Syracuse, N. Y., on account of ill health.

Major Clarke has been an exceedingly capable and conscientious officer, and his illness is largely due to overwork while in office.

WILLIAM SMITH has been appointed Superintendent of Motive Power of the Chicago & Northwestern Railway, to succeed the late Mr. G. W. Tilton. Mr. Smith was for three years Mr. Tilton's assistant, and was previously a division master mechanic on the road.

A. J. CASSATT, of Pennsylvania; HENRY G. DAVIS, of West Virginia, and GEORGE M. PULLMAN, of Illinois, have been appointed by the President Commissioners on the part of the United States to locate and organize the Intercontinental Railroad, as provided at the recent Pan-American Conference.

CHARLES MACDONALD, the well-known bridge engineer, has presented to the Rensselaer Polytechnic Institute a fund sufficient to yield $120 yearly, which is to be given to the student presenting the best graduating thesis containing an original design or an original investigation of some process of interest to engineers.

J. A. DAVENPORT is appointed Engineer of Maintenance of Way of the Georgia Pacific Railroad, having charge of the First Division, from Atlanta, Ga., to Birmingham, Ala. J. C. MOTLEY is also appointed Engineer of Maintenance of Way, having charge of the Second Division, from Birmingham, Ala., to Columbus, Miss. The office of Chief Engineer is abolished.

J. T. HARAHAN has been chosen Second Vice-President of the Illinois Central Railroad Company, and will have charge of the operation and maintenance of the road. He has served on the Louisville & Nashville, the Chesapeake & Ohio, the Lake Shore & Michigan Southern, and other roads, and was recently General Manager of the Louisville, New Orleans & Texas Railroad.

PROCEEDINGS OF SOCIETIES.

American Institute of Mining Engineers.—The 57th meeting began in New York, September 29. After the usual opening proceedings a paper on Explosions from Unknown Causes was read by J. C. Bayles. This was followed by papers on the Use of Electricity in Mining, Metallurgy, etc., by John C. Fowler, F. H. McDowell, C. Jones, C. M. Ball and others, and by a paper on the Iron Mountain Mine, by Professor William B. Potter. A number of papers were also read by title.

On September 30, two sessions were held, both being devoted to the reading of papers. Those read included one on Electric Power Transmission in Mines, by H. C. Spaulding; on the New Drifton Breaker, by Eckley B. Coxe; on Machinery for Charging Furnaces, by S. T. Wellman; on Pneumatic Hoisting, by H. A. Wheeler; on Copper in the United States, by James Douglas, Jr., and on Recent Improvements in German Steel Works, by R. M. Daelen, of Dusseldorf, Germany. A number of other papers were also read by title, and Mr. A. Fteley decribed the principal features of the New Croton Aqueduct.

This concluded the separate meeting of the Mining Engineers, the remainder of the meetings being held in connection with the British Iron & Steel Institute.

Iron & Steel Institute.—The first session of the American meeting began in New York, October 1, and was practically devoted to addresses of welcome from American Engineers and manufacturers and to appropriate responses from the visitors. Sir James Kittson also made the Presidential address, and announcements were made of the programme prepared for by the local committee.

A number of papers were also read, including one by James Gayley on American Blast Furnaces and another by Burdett Loomis on Fuel Gas. Both of these papers were discussed at great length by the American and Foreign engineers. Professor Henry M. Howe read a paper on the Bessemer Process; Professor E. Thomson one on Electric Welding, and Dr. C. B. Dudley one on the Wear of Metal as Influenced by Its Chemical and Physical Properties. A number of other papers of much interest were also presented and read either in full or by title.

On Thursday, October 2, the ceremonies attending the dedication of the Holley Memorial took place. In the afternoon an address was delivered in Chickering Hall by Mr. James Dredge, Editor of *Engineering*, who was long an intimate acquaintance of Mr. Holley, and who made an interesting address. The remaining ceremonies took place in Washington Square, where the memorial is placed; it is a colossal bronze bust by J. Q. A. Ward, placed upon a handsome pedestal, with appropriate inscription.

In the evening the annual banquet of the Iron & Steel Institute took place at Delmonico's.

On October 3 the members separated into parties and spent the day in visiting points of interest in the city and its neighborhood. On the morning of October 4 they started for Philadelphia in two special trains. In that city they were received by the Local Committee, Mr. Joseph D. Potts, the Chairman, making an address of welcome, which was responded to by Sir James Kittson. After lunch the members were taken by steamboat to Chester, Wilmington and other places on the Delaware.

Monday, October 6, was devoted to visits to various manufacturing establishments in Philadelphia and neighborhood, and October 7 to a trip to Lebanon, Pa., the Cornwall Iron Mines and blast furnaces and Mount Gretna Park.

The International Meeting, which included members from the British, American and German Societies was held in Pittsburgh October 9 and 10. After the opening proceedings a large number of papers of much interest were read, including a letter from Sir Henry Bessemer, giving an account of the discovery of the Bessemer process; one by Sir Lowthian Bell on the Probable Future of the Iron Manufacture; one by Sir Nathaniel Barnaby on the Protection of Iron and Steel Ships; on the Marine Engine, by A. E. Seaton; Dr. Hermann Wedding on German Practice with Iron and Steel; Professor John W. Langley on International Standards for Analysis of Iron and Steel and others, all being discussed.

Considerable time was spent by the members in visiting the points of interest in Pittsburgh and vicinity. At this point they separated into two parties, one going westward to Chicago and the other South to visit the coal and iron regions of that section in accordance with the programme which had been previously announced.

American Society of Railroad Superintendents.—The 19th meeting of this Association was held in New York, October 7, with a large attendance. The Secretary and Treasurer presented their annual reports. The Executive Committee made several recommendations, which were approved.

The following officers were elected for the ensuing year: President, H. Stanley Goodwin, Lehigh Valley Railroad; First Vice-President, R. G. Fleming, Savannah, Florida & Western; Second Vice-President, C. W. Bradley, West Shore; Secretary, C. A. Hammond, Boston, Revere Beach & Lynn; Treasurer, R. M. Sully, Atlantic Coast Line; Members of Executive Committee, C. S. Gadsden, Charleston & Savannah; O. E. McClellan, Pennsylvania; O. M. Sheppard, New York, New Haven & Hartford; A. B. Atwater, Chicago & Grand Trunk.

The Committee on Machinery made a report on Car Heating, and the system of the Morton Safety Heating Company of Baltimore was explained.

Mr. W. G. Wattson read a paper on Systematic Handling and Distribution of Freight Cars, and Mr. C. A. Hammond read one on Signalling. The latter was discussed and it was resolved to appoint a Committee on Signalling, the President naming F. K. Huger, J. J. Turner, J. Donelly, C. H. Platt and C. A. Hammond.

At the afternoon session Mr. H. H. Westinghouse read a paper on Recent Improvements in Air-Brakes, which was discussed by the meeting. Mr. James Churchward read a paper on Rail Fastenings. The remainder of the session was taken up by a discussion on Train Rules.

Several changes in the Constitution were proposed, which under the rules will not be acted upon until the next meeting. The thanks of the Society were voted to the retiring President, Major Gadsden.

General Time Convention.—The fall meeting was held in New York, October 8. The day fixed for the change of time was November 16. The Executive Committee reported that 169 companies, operating 121,442 miles of railroad, were now members of the Convention.

The President, Colonel H. S. Haines, made an address in which he suggested some improvements in train rules, and also spoke of the importance of adopting the *per diem* system of payment for cars. He also referred at some length to the important work of the Committee on Safety Appliances.

The Car Service Committee made a report giving statistics of car movement from a number of roads. It was stated that there are now 27 demurrage associations in successful operation, the form of agreement suggested by the Time Convention being generally adopted. The Committee recommended no action concerning *per diem* service payments.

The Committee on Safety Appliances made a long report submitting a synopsis of the Legislation adopted in the United States on Safety Appliances. The Committee recommended the adoption of the Master Car Builders' automatic coupler as the

standard for all members of the Convention. The next subject to be taken up will be that of Train Heating, upon which careful investigations will be made during the coming winter. This report was adopted with only two negative votes. The Committees on Car Service and Safety Appliances were continued with the same members.

American Society of Civil Engineers.—At the regular meeting, October 1, invitations were received to join in the meetings and excursions of the Institute of Mining Engineers and the Iron & Steel Institute. The Secretary announced the death of several members.

A paper, by J. F. Le Baron, on the Fallacy of the Contract System of Government Land Surveys, was read and discussed.

The tellers announced the following elections : *Members :* G. Aertsen, Latrobe, Pa.; William S. Bacot, New York ; George J. Bailey, Albany, N. Y.; Charles B. Ball, Washington ; Percy M. Blake, Hyde Park, Mass.; John B. Bott, Albert N. Connett, Baltimore, Md.; Herbert F. Dunham, Cleveland, O.; Oscar A. F. Saabye, Roanoke, Va.; Archibald A. Schenck, New York ; Hood Tucker, White Story, Tenn.

Associate : P. H. Griffin, Buffalo, N. Y.

Juniors : Robert A. Cummings, Roanoke, Va.; Charles R. Beltes, Hoboken, N. J.; Richard S. St. John, Princeton, N J.; Homer R. Stanford, St. Louis, Mo.; William C. Hawley, Chicago, Ill.; Ezra B. Naylor, New York.

At the meeting of October 15, Mr. W. E. Worthen presented a paper on Steam Heating. Mr. J. B. Francis made some supplementary remarks on the same subject, which was further discussed by a number of members present.

Boston Society of Civil Engineers.—At the regular meeting, October 15, Mr. E. S. Dorr exhibited and explained a diagram for determining sizes of sewers.

Mr. A. F. Noyes and Mr. H. D. Woods described the additions to the Newton Water Works with reasons for building the same.

Mr. H. H. Carter read a paper on the Settlement of Large Embankments, with special reference to the one between Moon Island and Squantum in Boston Harbor. All these papers were discussed.

Engineering Association of the Southwest.—At a meeting held in Chattanooga, Tenn., October 10, the Committee on the Cause of Setting of Cement submitted a report prepared by Dr. W. L. Dudley, of Nashville.

Mr. James A. Fairleigh gave an account of the new Tennessee River Bridge at Chattanooga, illustrated by drawings and maps. This was discussed at some length.

Messrs. Joseph C. Guild and William Bowron explained the Geology and Mineral deposits of the Chattanooga districts to visiting members.

Western Society of Engineers.—At the regular September meeting in Chicago, R. B. Bourland, C. F. T. Kandeler, Edward L. Abbott and Charles H. Miller were elected members.

The special topic for the meeting was the Site of the World's Fair, which was discussed at great length by members present.

Denver Society of Civil Engineers & Architects.—The Annual Convention of this Society was held at Manitou, Col., October 10, and continued on the following day. The members left Denver on the afternoon of October 10 and held their first session in the evening of that day. On the following day another meeting was held and a trip over the Pike's Peak Railroad was taken. Other places of interest in the neighborhood of Manitou were also visited, and the Convention closed with the annual supper in the evening.

Technical Society of the Pacific Coast.—At the regular meeting, September 5, in San Francisco, Mr. Calvin Brown read a paper on Calcareous Cements, giving investigations both chemical and experimental into the nature of such cements. The paper was accompanied by a number of photographs of cement and concrete work erected in France.

At the regular meeting, October 3, Mr. H. C. Behr read a paper on Experimental Works for Ores Requiring Forced Concentration, which had a special interest for those engaged in mining.

Master Car Builders' Association.—A circular from Secretary John W. Cloud announces the result of the letter ballots ordered at the last Convention.

The Journal-box for 60,000 lbs. cars and the Lid for the ordinary journal-box were rejected, not having received a two-thirds vote.

The following standards were adopted, all having received a considerable vote over the necessary number : Method of Loading Logs and Poles on Cars ; Racking Cars for Loading Bark ; Height of Draw Bar for Passenger Equipment Cars, 35 in.; Safety Chains for Passenger Equipment Cars ; Brake Beam Lever, Lateral Angle 40°; Fitting for Train Pipe for Steam Heating ; Two-Inch Female, Standard Pipe Thread.

Master Car & Locomotive Painters' Association.—The Annual Convention of this Association, which was held in Boston in September, was largely attended, and much practical work was done there. Among the questions discussed were the Benefit to an Undercoat of Paint of an Egg-shell Gloss ; Best Method of Testing Japan ; Treatment of Hard and Soft Woods ; Best Paint for Preventing Rust on Metal ; Best Method of Removing Old Paint ; Most Economical Method of laying Gold Leaf ; Durability of Varnish ; Hard and Soft Wood Finish ; Tests of Paint and Varnish ; Striping and Lettering ; all interesting and practical topics.

It was decided to hold the next Convention at Washington. The following officers were elected for the ensuing year : President, Joseph J. Murphy ; Vice-Presidents, E. L. Fetting and A. S. Coleman ; Secretary and Treasurer, Robert McKeon.

New England Railroad Club.—At the October meeting, in Boston, the subject for discussion was Steel Tired Wheels, with special reference to equalizing wear, and to machinery for turning up the tires. The discussion was opened by Mr. Lauder, who spoke at considerable length, giving his experience. Messrs. Marden, Snow, Adams, Clarke and others took part in the discussion, the general opinion being that the brake-shoe used made a very great difference in the wear.

Western Railway Club.—At the regular meeting in Chicago, September 16, the subjects of Rigid Center and Swing Beam Trucks for Freight Cars and Flange Wear of Wheels were discussed by members present, a great deal being said on both sides and strong opinions expressed especially in favor of the rigid truck.

The following officers were elected for the ensuing year : President, J. N. Barr ; Vice-Presidents, C. A. Schroyer and P. H. Peck ; Treasurer, Allen Cooke ; Secretary, Walter D. Crosman. A vote of thanks to the retiring officers was passed.

Northwest Railroad Club.—At the regular October meeting in St. Paul, Minn., the first subject for discussion was Brake Beams, upon which a paper was read by Mr. H. L. Preston. This was discussed by members present, who gave their experience at considerable length.

NOTES AND NEWS.

The New German Rifle.—The greater portion of the German Army and Navy has been armed with the new rifle in the course of the last few months, and the issuing of the weapon continues. This is the fifth change of arms made by the German Government in the last 50 years. The new rifle is the design of the Experimental Arms Commission, appointed some time ago, and charged to report a small caliber arm suited to German troops. The report favored a rifle of 7.9 mm. (0.31 in. caliber) of the Männlicher type.

The most interesting feature in the new arm is in connection with the barrel. The commission believed that want of accuracy was often due to irregularity of dilatation. It was, therefore, resolved to free the barrel as much as possible from extraneous matter, such as fittings and aiming apparatus. In the new rifle the barrel is inclosed in a tube on which are fixed the breech and front sights, with a space of a demi-millimeter between the tube and the barrel. The projectile is a mere kernel of hard lead, cylindro-ogival in shape, and having a steel-nickel coating. It weighs 14.5 grams. The cartridge weighs 27.5 grams. Its length is 82.5 mm. (3.25 in.). The magazine with its five cartridges weighs 154 grams. The soldier or blue jacket carries in each cartridge box in front two magazines, with six in the cartridge box behind. He has thus 150 cartridges, representing a weight of 5.030 kilos (11.09 lbs.).

The initial speed of the projectile is 620 meters, and the limit of its range, at an angle of 32°, is 3,000 meters. At 100 meters it passes through a block of deal of 80 cm. thickness, and at 1,800 meters it perforates a plank of this wood 5 cm. in thickness. At 300 meters it passes through an iron plate of 7 mm. At 2,000 meters, after ricochet, it buries itself from 2 to 3 cm. At 200 meters it pierces a cuirasse in its strongest part.

Experiments show that an earthwork parapet cannot afford shelter unless it has a thickness of 0.75 meters at least. Brick walls of small thickness are not absolute proof against the ball; several shots striking the same spot will make a breach. Six haversacks completely charged and placed one behind the other were pierced from end to end by every shot fired at them.

The Cernavoda Bridge.—This bridge, for which the contract was let to the Fives-Lille Company of France, for the sum of $1,527,000, will be the first bridge over the Danube eastward of Neusatz, near the mouth of the river Theiss. Cernavoda, as well as the Black Sea harbor of Kustenji, are situated in the Dobrudsha, the new Roumanian province, and both are connected by a railroad about 40 miles long. The object of the bridge is to continue this railroad westward into Roumania. About 90 ft. below low-water lime-stone rock is found, and the foundations of the piers, whose crown is about 120 ft. above low water, go down to the rock. The bridge—a single-track bridge—consists of five spans: 459, 459, 623, 459, and 459 ft. Spans two and four are girders, 55 ft. 9 in. deep in the center, and 105 ft. over the piers; cantilevers 164 ft. long project beyond the piers into the first, third and fifth spans; there is consequently left in each of these spans an opening of 295 ft., which is bridged over by a semi-parabolic girder 42 ft. 8 in. deep in the middle and 29 ft. 6 in. at the ends. On the two middle piers are fixed bearings, and on the four remaining supports are roller-bearings; a movable bearing is also at one end of the central girder of 295 ft. span.

The principle of the cantilever, as described above, was adopted after various other principles had been proposed, and after it had become evident that a clear headway for navigation of about 100 ft. throughout was required, and that neither a continuous girder nor an arch bridge would have been practicable. The design is by Mr. Saligny, Engineer to the Roumanian Government.

The material for the girders is basic Martin ingot steel, of a tensile strength of from 27 to 30 tons, with 16 to 21 per cent. elongation. The strain per square inch from the load is not to exceed 6.36 tons per square inch, and from load and wind-pressure together 7.64 tons. The wind-pressure is assumed at 50 lbs. per square foot on the bridge without the load, and 37 lbs. on the bridge with the load. The bending strains in some of the long members arising from their own weight amount to 1.2 ton per square inch in the diagonals, and to 1.22 ton in the flanges, and they have been taken account of in determining the sectional areas. Other conditions of strength, and various conditions as to the manipulation of the material, are of interest.

As in the Forth Bridge, the transverse bracing between the top flanges of the cantilever girders is omitted, and this is described as having several advantages. The distance between the cross-girders varies between 42 ft. 8 in. and 23 ft. 8 in., and they are plate-girders with 5.7 tons strain per square inch. The stringers are 7 ft. 10½ in. apart, and upon them an iron trough-flooring is laid. The sleepers, 9½ in. wide and 6 in. deep, lie in the troughs bedded in gravel.

The weight of steel in the superstructure is 3,385 tons; that of the trough-flooring 226 tons, and that of the gravel-packing, sleepers, etc., 325 tons; a total of 3,936 tons in 2,460 feet, or 1.6 tons per foot lineal. The iron caissons will weigh 887 tons. The four piers will contain 1,214,250 cubic feet of stone masonry, and 13,054 cubic yards of concrete.

A Substitute for Forced Draft.—The British Admiralty has made a series of trials to test Martin's system for securing the rapid development of steam without endangering the stability of the boiler, which is a practical reversal of the forced draft system. He proposes to place a fan at the root of the funnel, so that the hot air may be sucked through the tubes instead of being forced through them by the operation of fans in the stoke-hole. By this means, he contends, the stoking will be rendered less difficult and laborious, and the impinging of the blast upon tube plates will be considerably lessened, if not wholly prevented. The boiler selected for the experiment was one of a locomotive set originally belonging to the *Polyphemus*. The results demonstrate, it is said, that with induced draft, which closely approximates to the railroad system, a marine boiler is capable of steaming at a much higher rate than with forced air, and with perfect safety, and that the maximum power, which is now confined to four hours at the utmost, can be indefinitely continued for the longest voyage. The boiler at the end of the steaming was found to be in such good condition that it is proposed to test it with forced draft.

Superheating Steam.—In describing a visit to Logelbach, the home of M. Hirn, a writer in *Industries* refers to an arrangement for superheating steam in an engine which has been in use for forty years. This plan of M. Hirn's was one of the first put to the test and practically applied, is still always in use, and is considered to give a greater economy of feed water than the steam jacket. The amount of superheating is about 140° Fahr. The superheating apparatus consists of a series of pipes, and is invisible, as it is placed toward the end of the boiler, where the hot gases play constantly over its surface. This method involves no additional expenditure of fuel or labor. The mere fact that the superheating arrangement has been in constant operation for so many years, without more detriment to the valves, gear, etc., than is incidental to any engine when at work, proves that the system is of real practical advantage, and deserves more attention than it has hitherto received.

A Universal Cement.—A cement of universal adaptation, that is readily and permanently adhesive to any substance, has long been a desideratum, and to its realization Professor Alexander Winchell appears to have successfully directed his skill as a chemist. His method is to take two ounces of clear gum arabic, one and one half ounces of fine starch, and one half ounce of white sugar, the gum being then pulverized and dissolved in the same quantity of water as is commonly employed in laundry operations for the quantity of starch indicated, and both starch and sugar are dissolved in the gum solution, the mixture being now suspended in a vessel in boiling water until the starch becomes clear. The cement should be as thick as tar, and remain so, prevention from spoiling being insured by dropping in a lump of gum camphor or a little oil of cloves or sassafras. This cement is so very strong and tenacious that it will hold immovably to glazed surfaces, will repair broken rocks, minerals, and fossils, and has innumerable adaptations in the mechanical and industrial arts.

Quadruple Expansion.—Mr. Robert Carson, of Hull, in writing to a foreign paper, mentions as a practical illustration of the advantages of quadrupling, his own experience with the steamship *European*, trading between the above port and Amsterdam. The old engines, he states, were a good sample of an economical working compound, indicating about 480 I.H.P., the average consumption of coal for all purposes for the voyage out and home being 32 tons. After quadrupling, and replacing the boiler by one of his own special design, the engines indicated 540 H.P., and the consumption of fuel was reduced to 20 tons per voyage for all purposes, thus making a saving of 12 tons per voyage. He accordingly advises the shipowner who is despondent over being the possessor of a steamer the engines of which are becoming obsolete, to quadruple their old engines, and thereby obtain the necessary economy to enable the old vessels to compete with those of more modern type. Another important saving besides the reduced fuel consumption, he mentions, results from the reduction in deadweight carried about continually by the vessel. The boiler, he says, is small; uptake, casings, fittings and water in the boiler reduced, as well as the quantity of bunker coals required for the voyage. This, in the case of the *European*, amounted to as much as 37 tons.

Smoke Prevention.—The Society of German Engineers has arranged to offer two prizes of $720 each for the best papers on smoke prevention, one for steam boilers, and one also for domestic furnaces, with additional prizes of $240 for drawings.

Old Compound Engines.—M. Kraft, Chief Engineer of the Works of the Société John Cockerill, at Seraing, Belgium, has sent us the following note made by him during the recent trip to Russia. On this trip he saw on the Volga River three tow-boats—the *Sampson*, the *Hercules* and the *Volga*—furnished with compound engines, built by Roentgen at the Fijnoord Works, in Rotterdam, Holland. These boats were ordered in 1845 and delivered in 1847, and the frame carries the latter date cast in the iron.

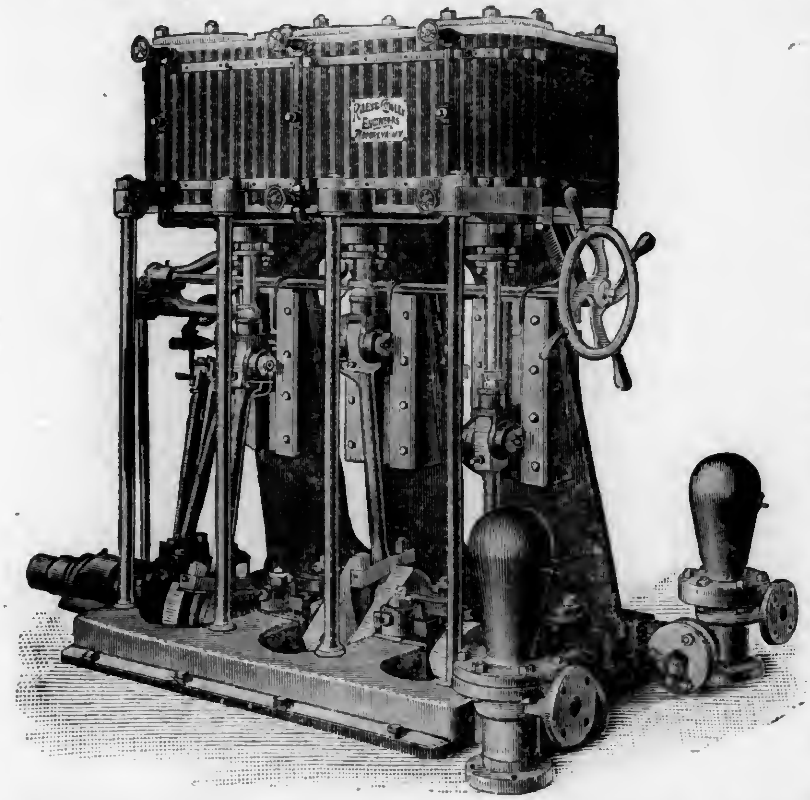
The cylinders are fixed, placed opposite to each other and inclined, with the connecting-rods working the same crank. A long steam pipe joins the opposite cylinders, forming an intermediate reservoir, a plan often adopted in later engines. The steam pressure carried was originally 95 lbs., but the boilers have since been changed, and the working pressure at present in use is 120 lbs.

The high-pressure cylinder is 30½ in. in diameter and the low-pressure cylinder 60½ in., the stroke being 7 ft. The cyl.n ers

are furnished with piston valves. The frame is of wrought-iron plates and angles, with a cast-iron base.

These engines are said to have developed 800 H. P. They have been at work without renewal, with only ordinary repairs, since they were first built, but the boilers originally put in have been replaced by new ones. M. Kraft found on the *Sampson* in April last a chief engineer, originally from the Rhenish provinces, who had run the engines for 30 years.—*Memoires de la Société des Ingenieurs Civils, Paris.*

A Small Triple-Expansion Engine.—The accompanying illustration shows a triple-expansion engine built by Riley & Cowley, of Brooklyn, N. Y., for the steel steam launch *Lillian*, now under construction by the Jonson Foundry & Machine Company, New York. The *Lillian* is 65 ft. long, and is driven by a screw 31 in. in diameter and 48 in. pitch. The engine is characterized by simplicity of construction and accessibility of parts, and from these features may be considered as peculiarly adapted to service of this nature. As the cut shows, the slides and moving parts are readily accessible from the starboard side. It is a triple-expansion engine, with 4-in., 6½-in. and 10-in. cylinders and 8 in. stroke. There are three cranks set at an angle of 120° with each other. The high pressure and intermediate cylinders have piston valves, the low-pressure a slide valve, worked by eccentrics set upon a sleeve that is free to rotate upon the shaft. In the sleeve a spiral groove is cut, and in the shaft a straight keyway.



It is evident that a pin engaging both of these slots, on being moved in one or the other direction along the line of the shaft, would rotate the sleeve carrying the three eccentrics. Such a pin is provided, attached to a second short sleeve that slides freely outside of the other one. It is moved back and forth by rack and pinion movement, so as to turn the eccentrics one way or the other, reversing the engine whenever desired without the use of the complication involved in ordinary link motion.

The estimated H.P. is placed at 75, giving 450 revolutions with a steam pressure of 160 lbs. to the square inch. There are independent air, circulating and feed pumps. The surface condenser contains 120 square feet of cooling surface.—*American Shipbuilder.*

Aluminum in Alloys.—In his address as President of the British Association for the Advancement of Science, Sir F. A. Abel recently made the following remarks :

" It appears to be already established that the modifications in some of the physical properties of steel resulting from the addition of aluminum are not merely ascribable to its actual entrance into the composition of the steel, but are due, in part, to the deoxidation by aluminum of some proportion of iron oxide which exists distributed through the metal, and prejudicially affects its fluidity when melted. In the latter respect, therefore, the influence exerted by aluminum, when introduced in small proportions into malleable iron and steel, appears to be quite analogous to that of the phosphorus, silicon, or lead when these are added in smaller proportions to copper and certain of its alloys, the deoxidation of which, through the agency of those substances, results in the production of sound castings of increased strength and uniformity. It is only when present in small proportion, in the finished steel, that aluminum increases the breaking strain and elastic limit of the product. The influence of aluminum, when used in small proportion, upon the properties of gray and white cast-iron, is also of considerable interest, especially its effect in promoting the production of sound castings, and of modifying the character of white iron in a similar manner to silicon, causing the carbon to be separated in the graphite form ; with this difference, that the carbon appears to be held in solution until the moment of setting of the liquid metal, when it is instantaneously liberated, with the result that the structure of the cast metal and distribution of the graphite are perfectly uniform throughout. . . .

" At the celebrated French Steel Works of M. Schneider, at Creuzot, the addition of a small percentage of copper to steel used for armor-plates and projectiles is practised, with the object of imparting hardness to the metal without prejudice to its toughness. James Riley has found that the presence of aluminum in very small quantities facilitates the union of steel with a small proportion of copper, and that the latter increases the strength, but does not improve the working qualities of steel. With nickel, Riley has obtained products analogous in many important respects to manganese steel ; the remarkable differences in the physical properties of the manganese alloys, according to their richness in that metal, are also shared by the nickel alloys, some of these being possessed of very valuable properties ; thus, it has been shown by Riley that a particular variety of nickel steel presents to the engineer the means of nearly doubling boiler-pressures, without increasing weight or dimensions. He has, moreover, found the co-existence of manganese in small quantity with nickel in the alloy to contribute importantly to the development of the valuable physical properties."

A Ship Canal to Paris.—A plan has been prepared by M. Bouquet de la Grye, a distinguished French engineer, for making Paris accessible to ships of considerable size. The improvements now in progress in the lower Seine will give a depth of 20.34 ft. of water up to Rouen, and M. de la Grye proposes to convert the river from that point up to Paris into a ship canal. This would be divided into five levels by four locks. The first would extend from Rouen to Poses, 14.31 miles, where a lock of 20.7 ft. lift would begin the Vernon level. This would extend to Mericourt, at which place a lock of 22 ft. lift would begin the Poissy level, 26.97 miles long, to Poissy, where a third lock of 13.87 ft. lift would rise to the Sartrouville level, 11 miles long, running to the fourth lock, of 10.5 ft. lift, which would begin the St. Denis level, the last 13.34 miles in length, the end of the canal being at the Bridge of Clichy, in Paris.

The plan is for a uniform depth of 20.34 ft. of water, the width to be 115 ft. on tangents and 148 ft. on curves ; the minimum radius of curvature to be 5,000 ft. The course of the river would be followed, with only a few necessary changes to avoid sharp bends, except at Oissel and Besons, where some cutting would be done to avoid draw-bridges. The supply of water is said to be abundant.

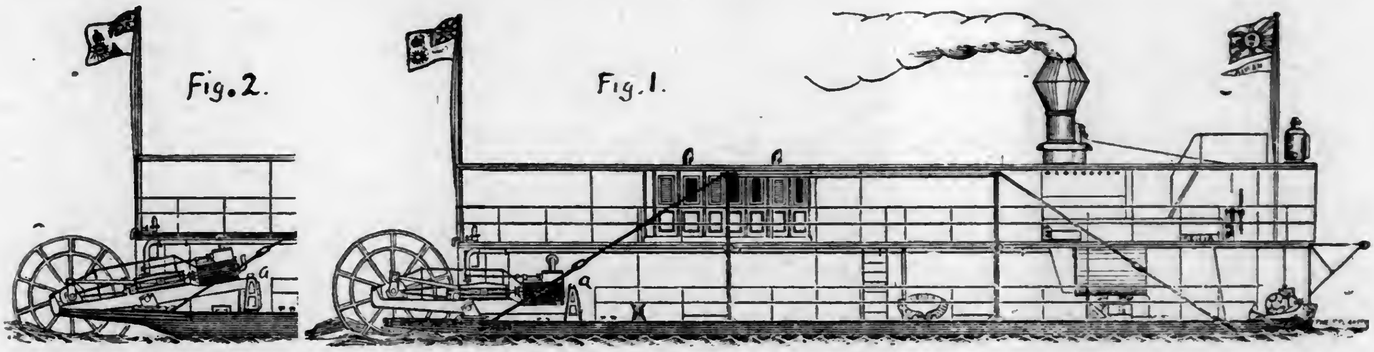
M. de la Grye estimates the cost of the proposed work at $27,000,000 ; the time required for the execution of the necessary works would be about three years. The commercial advantages, it is claimed, would be very great, as Paris would be made practically a seaport.

Painting.—It is found that in painting wood one coat takes 20 lbs. of lead and 4 gals. of oil per 100 sq. yds. ; the second coat, 40 lbs. lead and 4 gals. of oil, and the third the same as the second, say 100 lbs. of lead and 16 gals. of oil per 100 sq. yds. for the three coats. The number of square yards covered by one gallon of priming color is found to be 50 ; of white zinc, 50 ; of white lead paint, 44 ; of lead color, 50 ; of black paint, 50 ; of stone color, 44 ; of yellow paint, 44 ; of blue color, 45 ; of green paint, 45.

A New Stern-Wheel Steamboat.—The accompanying illustration—from the *Steamship*—shows the stern-wheel steamboat *Kenia*, built by Kincaid & Company, Greenock, Scotland,

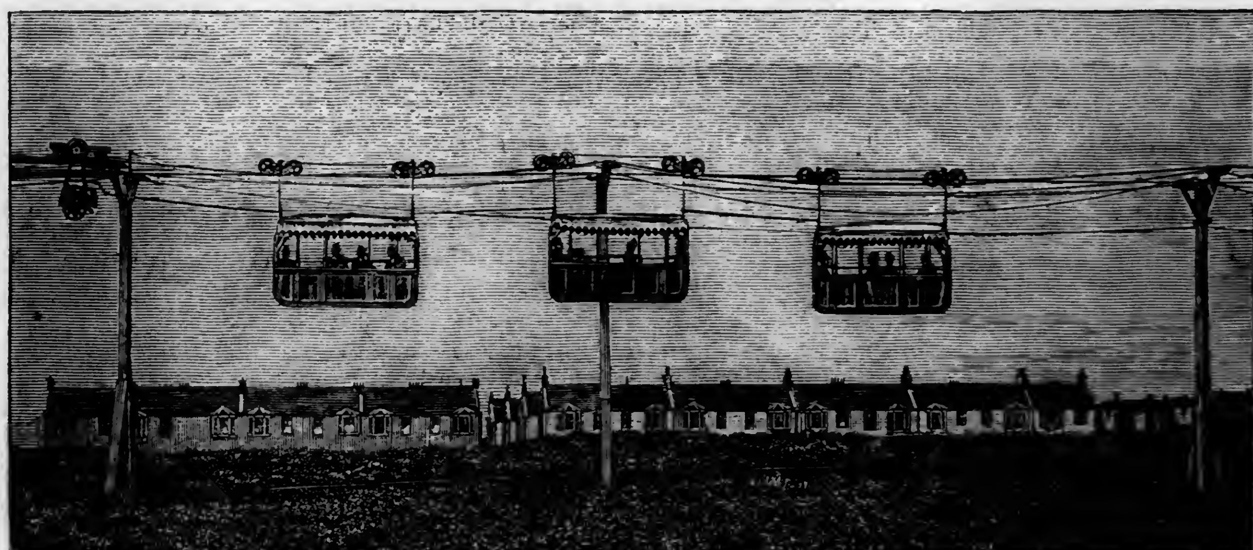
for use on the Tana River in East Africa. The *Kenia* has a steel hull, is 80 ft. long and 21 ft. broad, and has a draft of 18 in. light and 39 in. when fully loaded. The engines are compound, and use steam at 120 lbs.

The peculiarity of the boat is the arrangement by which the wheel can be adjusted at the best depth, no matter what the draft; this is patented by Mr. Kincaid, in England. In the illustrations fig. 1 shows the boat loaded down to her greatest draft, while fig. 2 shows the stern when running light. As will be seen, the engines and the wheel are mounted on a frame which is carried on trunnions near the center, and which can be adjusted at any angle, within a sufficient range, by means of the standard frame *a*. The weights are so nearly balanced that only a very small force need be applied to alter the angle of the frame. In this way the wheel can be kept immersed to about the same depth, no matter what the draft may be. The arrangement seems to be a very convenient one for a small boat.



A Diminutive Electric Light and Power Station.—Collias, near Nîmes, a village of 465 inhabitants, has just been lighted by electricity. The motive power for the 1,600-light dynamo is derived from a small waterfall. The streets are lighted by 25 lamps of 16 candle-power each. Besides lighting the village, the current is employed during the day in putting in motion the pumps for supplying certain parts of the village with water.

The Telpher Line at Edinburgh.—The Telpher line put up at the Edinburgh Exhibition by the Electrical Engineering Corporation shows the most recent improvements, and is arranged so as to carry passengers as well as demonstrate the advantages of the system for this transport of goods.

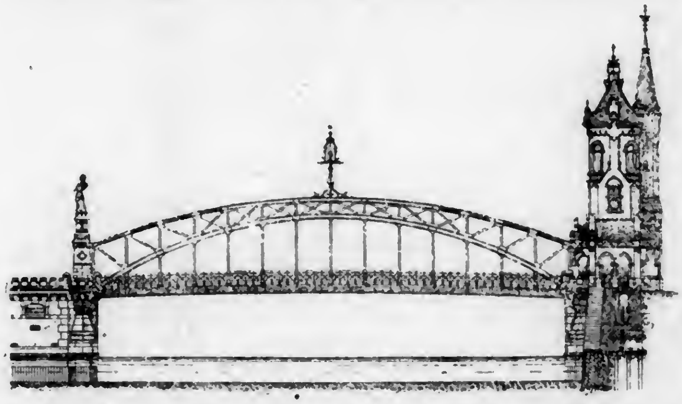


The Edinburgh line consists of over a quarter mile of track, the flexible portion of it being constructed in spans of 50 ft. and the rigid ends in spans of 15 ft. The stand-ropes on which the locomotive and carriages travel are of crucible steel and $1\frac{1}{8}$ in. in diameter. These are tightened, so that with a full load on the line there is a sag of about 2 ft. $4\frac{1}{2}$ in. on the spans covered by the train. The arms supporting the stand-rope are arranged so that they move in either direction, allowing the sag in the rope to follow the train as it moves along, thus not putting any undue strain upon the posts themselves. The stand-rope at its junction with the rigid rail passes from a special descent junction saddle so arranged that the train rises from the rope on to the rigid rail without any jerk or other unsatisfactory movement. From the junction saddle the stand-rope passes direct to a structure termed the abutment post; this is fastened to the substantial anchorages in the ground by flexible steel ropes 5 in. in circumference. The strain upon the ends of the stand-rope with a fully loaded train is about five tons, and the strain upon the anchorages about eight tons. The current is conducted along a conductor which is not attached to the insulators on which it rests at any point, but merely rests upon them. From the locomotive a rigid arm projects underneath the conductor, but above the insulators, and slides along under the conductor, lifting it off the insulators as the arm passes them, allowing it to rest on them again after it has passed.

The train, as will be seen from the illustration, is a very practicable one; the cars, which with the plant and the rest of the equipment were made at the works of the Electrical Engineering Corporation at West Drayton, are built much in the fashion of railroad carriages, each car having two compartments and holding four persons, and each compartment being entered from a door with a latch. The whole of the car is suspended by iron hangers from two trucks, the bodies of which latter consist of mitis iron castings resting on the axles of the wheels at each end. The hanger does not depend directly from the body of the truck, but rests upon two vertical springs contained in boxes on each side of the body.

The locomotive consists of what is termed by the builders a swinging tub, and the motor drives a small countershaft, to one end of which is attached an electrical governor to maintain a set speed; the other end of the countershaft has upon it a chain-wheel, which drives directly upon a larger chain-wheel contained on the upper frame. The motor is suspended from the upper frame by a hanger, so arranged as to allow the whole to swing, the swinging movement thus allowed not interfering with the motion of the chain, as it is a movement radially to the center of the large chain-wheel on the upper frame. The upper frame contains, in addition to the large chain-wheel, two driving-wheels with malleable cast iron tires to grip the rope, each attached to a chain-wheel driven from the shaft supporting the large central chain-wheel.—*London Electrician.*

A German Bridge.—The accompanying cut represents a bridge recently erected to carry a street over the Zoll-canal in Hamburg, Germany. It presents no special features of construction, but is notable for its neatness and elegance of design. It is obviously a bridge; that could not well be concealed, but the general effect on the eye is good enough to satisfy even our



exacting friends, the architects and poets, who have been finding so much fault with engineering structures lately, and denouncing engineers as Vandals who destroy the beauty of a landscape.

A French Fast Train.—A new locomotive built in the shops of the Northern Railroad has just been tried at high speed, with a special train of 16 carriages, having a total weight of 667,800 lbs. Lead bars were put in the carriages to represent the average weight of passengers, baggage, etc., carried on an express train.

This train ran from Paris to Calais by the direct line, a distance of 184.56 miles, in 3 hours, 53 minutes; two stops were made, one of five minutes at Amiens, the other of two minutes at Abbeville. The average speed, making no allowance for stops, was thus 47.53 miles an hour. The run from Paris to Amiens was made at the rate of 51.58 miles an hour, the train going up the Survilliers grade—0.5 per cent, 11.19 miles long—at the rate of 46.6 miles an hour.

On the return trip another carriage was added, making 17 in all. From Calais to Lille the average speed was 49.7 miles an hour, the highest speed 59 miles. Between Lille and Paris the average speed was about the same, but a speed of 71.46 miles an hour was reached in going down the Survilliers grade.

The Suez Canal.—The number of vessels passing through the Suez Canal at night by means of electric light is increasing with extraordinary rapidity. The regulations for the use of the electric light came into operation in March, 1887, and during the remainder of that year (according to statistics given in the recent British Consular report from Port Said) the number using it was 394. In 1888 the number rose to 1,611, and last year reached 2,445. Prior to March, 1887, the privilege of traveling by night with electric light had been restricted to vessels carrying the mails; since then all ships which conform to the regulations are allowed to proceed by night. The average time of transit has also been considerably shortened. In 1886 it was 36 hours; in 1887, 33 hours and 58 minutes; in 1888, 31 hours and 15 minutes; and in 1889 it had been reduced to 25 hours, 50 minutes. The average time for vessels using the electric light in 1889 was 22½ hours. The shortest time taken by a steamer in the transit of the canal in 1889 was 14⅙ hours, which is 10 minutes less than the fastest passage on record previously. —*Nautical Magazine.*

The Baltimore & Ohio Relief Department.—The annual report of the Relief Department of the Baltimore & Ohio Railroad Company, which is the successor of the old Relief Association, states that out of 20,626 members of the Association, 19,089 voluntarily became members of the Department. During the fiscal year 1889, benefits were paid to 10,922 persons the total amount being 296,103. These payments included 79 for death from accident; 3,442 for accidental injuries; 139 for deaths from natural causes; 4,929 for sickness, and 2,333 for surgical expenses. At the close of the year there were 19,894 members.

The pension feature shows that during the year $24,160 were paid to pensioners, of whom the total number on the list at the end of the year was 157.

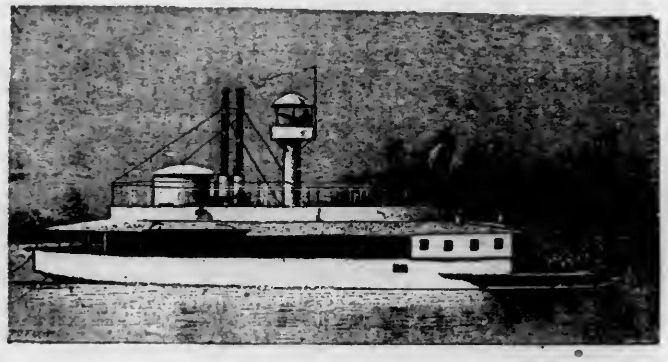
The savings feature shows total deposits of $435,553, the amounts received during the year being $149,576. The total amount loaned to employés since this feature was instituted has been expended in building 332 houses, buying 311 houses, improving 76 houses already owned and releasing liens in 169 cases.

Developing Alabama Ore-Beds.—The New South Mining & Manufacturing Company is now constructing a line known as the Tennessee River, Ashville & Coosa Railroad, which will extend from Decatur, Ala., to Lock No. 3 on the Coosa River, a distance of 100 miles. It crosses the Alabama Great Southern at Whitney, 102 miles from Chattanooga, and at Lock No. 3 connects with water navigation on the Coosa and with the East & West Railroad of Alabama. The road is built chiefly to reach the mineral deposits on the line, which include coal, limestone and iron ore of fine quality, both red and brown ore; there is also much good timber.

This is only one of several enterprises which show to how great an extent the southern mineral deposits are attracting attention in the North and elsewhere.

The Portelectric Railroad.—The so-called portelectric system, which was on exhibition in Baltimore not long ago, is now being tried in the neighborhood of Boston, where an experimental line 3,000 ft. long, in which are introduced several sharp curves and heavy grades, has been built. This system, which is intended to transmit packages, mail and similar matters at very high rates of speed, consists of a long car, shaped something like a cigar, running on a single rail, and kept in place by an upper guide. On the experimental road the car is 12 ft. long and 10 in. in diameter and weighs 350 lbs. The road is carried on posts and at intervals are placed coils of wire forming a series of rings through which the car passes, the track forming one part of the electric circuit and the wire in the coils the other. The electricity is generated by a dynamo placed in a power-house on the line. The principle of the road is that the car constitutes a magnet which is attracted or drawn forward by the coils of wire on the line, the apparatus being so made that the section of each coil draws the car within it, but just before it reaches the center by automatic action, the current is cut off. The motion of the car, however, continues, carrying it within reach of the attractive force of the next coil. The Boston projectors have much faith in this system, and believe that it can be applied advantageously for carrying mails and express matter between cities, and that a very high rate of speed can be attained.

A French River Gun-boat.—The accompanying illustration, from *Le Yacht*, shows the gun-boat *Berthe-de-Villers*, built for the French Navy, for special river service in Tonquin. It is a flat-bottomed boat modeled somewhat on American lines, and



propelled by a paddle-wheel at the stern, driven by two horizontal engines of ordinary pattern. The hull is of iron, and some protection is given to the crew and machinery by the bulwarks and shields, which are proof against rifle shots at ordinary ranges.

The boat carries several machine guns, one of which is mounted in the top, as shown in the picture, giving it a considerable range. While not of service against artillery of any weight, this gun-boat is strong enough to be formidable in forest or savage warfare, of the kind for which she is designed.

The Hudson River Bridge Company.—This company, which is to build a bridge over the Hudson at New York on the plans of Mr. Lindenthal, has been organized, with the following officers: President, Jordan L. Mott, New York; Secretary, M. H. Houseman; Treasurer, Charles J. Canda; Counsel, Charles F. McLean; Chief Engineer, Gustav Lindenthal. Other directors are: James Adams, Thomas F. Ryan, William Brookfield, New York; Edward F. C. Young, Jersey City, N. J.; John K. McLanahan, Hollidaysburg, Pa. The company is incorporated under acts of Congress and the Legislatures of New York and New Jersey.

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THE latest tunnel plan proposed is to connect Scotland and Ireland. The projector, Mr. Barton, proposes to start from a point on the coast of Wigtonshire and to run under the North Channel to a point on Magee Island. The distance under water is 33 miles and the greatest depth below sea-level would be 500 ft., the steepest gradient 1 in 75. Such examination of the bottom of the channel as has been possible shows, it is said, that it is very favorable for a tunnel, and the undertaking has the support of some eminent engineers. Its total cost is estimated at $40,000,000, and it would take 10 or 12 years to complete it. The great difficulty seems to be the question of ventilating so long a stretch of tunnel where no air-shafts are possible.

THE Russian Government proposes to devote a considerable amount to the improvement of the interior waterways. The first work to be done is on the Marie Canal system, which was originally intended to connect St. Petersburg with the Volga, but which has been of late years much neglected. This system consists of a number of short canals and of river channels, and it is now proposed to repair and enlarge the existing locks and dams and to deepen, widen and strengthen the channels. Other improvements are to be made with a view of accommodating the increasing traffic of the Volga, the Don, the Vistula, and other rivers, especially the Volga. There are not many canals in Russia, and most of them are short and built to connect the river systems; but the country possesses nearly 34,000 miles of navigable rivers, and some of them carry a very large commerce.

A proposition lately made is for a canal to connect Lake Onega with the White Sea near Archangel. This canal would have a length of about 160 miles, of which about 70 miles is already natural water-way, and it would, it is believed, benefit very much the northern provinces adjacent to the White Sea.

ACCORDING to a recent report the whole length of Russian Railroads is 17,693 miles, of which about one-fourth belongs to the Government. This includes only the lines in European Russia, and in addition to those may be counted the railroads of Finland, 1,135 miles, and the Trans-Caspian Line, 661 miles. The principal addition last year was the Pskov-Riga Line, 245 miles, and some shorter branches, amounting to about 50 miles in all.

THE consumption of wood for ties is attracting much attention in France, and the railroad companies are urged to employ metallic ties to a greater extent than they have heretofore done. The present demand for wooden ties exceeds the quantity which can be supplied from the forests of the country, and a large number have to be imported at considerable cost. Two or three of the great French companies have used steel ties and are increasing the number in their tracks, but the others have not heretofore favored the metallic ties.

THE New York Aqueduct Commission has decided to accept Chief Engineer Fteley's plan for the dam and reservoir which is to replace the present Croton Dam. This plan, as noted in our last number, is for the construction of a dam about a mile below the present one, which will make a reservoir about one-half the capacity of the proposed dam at Quaker Bridge, which has been so much discussed. The new Croton Dam will cost considerably less than half the amount estimated for the Quaker Bridge Dam, and can be built in a much shorter time, while it is considered that the storage capacity provided will be sufficient for the needs of the city for 20 years to come.

A CORRESPONDENT of the *American Manufacturer* calls attention to the opportunity for introducing small

American steamboats on the Amazon River. The navigation of that river is at present mainly in English hands, and all the larger boats were built in England and are operated by Englishmen, but it is believed that there is room for a number of smaller boats of American construction to serve as feeders for the main lines.

IN a paper recently presented before the New York Electrical Society, Lieutenant Bradley A. Fiske, who is well known from his work in connection with electrical ship appliances in the Navy, calls attention to the need of electrical engineers in time of war not only in the Navy, but for handling the apparatus used in forts and for harbor defenses. He believes that in case of war it would be very difficult to fill the demand, and advocates the formation of corps of naval and military electricians to assist the regular Army and Navy in its work. Such a corps, he thinks, might exist in every large seaport town, and might be accepted as a regular part of the National Guard in the same way as the Naval Reserve has been organized in New York and Massachusetts. With proper assistance from the Navy Department these electrical companies might be extremely useful, and there seems to be no reason why they should not be organized and receive the support of the Government.

THE Census Bureau reports that the total production of steel in the United States in the year ending June 30, 1890, was 4,466,926 tons, or more than four times the production in 1880. About 85 per cent. of the total—3,788,572 tons—was Bessemer steel; 504,351 tons were open-hearth steel; 85,536 tons crucible steel; 83,963 tons were made by the Clapp-Griffiths process, and 4,504 tons by the Robert process. Steel works are now located in 19 States, Pennsylvania having the leading place, with about 62 per cent. of the total production. Illinois is second in rank and Ohio third. In the last 10 years crucible steel has shown but a small growth, but the increase in Bessemer and open-hearth steel has been extraordinary. Nearly half the total steel made last year was converted into rails, but the increase in the use of steel for architectural and other purposes has been very marked.

THE most important engineering work now in progress in the vicinity of New York is the new elevated line of the Pennsylvania Railroad in Jersey City, where the Company is building practically an entirely new line from the east end of the cut through Bergen Hill to the station at the ferry. The new line, which is for passenger traffic only, will have when completed four tracks, and will pass part of the way through Jersey City on an embankment varying in height and enclosed between heavy walls of masonry, while for the rest of the distance it is carried on an elevated structure of iron, consisting of heavy plate girders supported by iron columns, with bridges across the streets.

In connection with this, the Company is building an entirely new passenger station in Jersey City, which will be elevated some 15 ft. above the street-level. The train-house in this station will be 256 ft. wide and 600 ft. long, and there will be ample waiting-rooms and other accommodations. Passengers will not be required to descend to the street level, as all the Company's ferry-boats are to be provided with an upper deck, upon which they can pass from the station, while the necessary alterations will be made in the ferry-houses in New York also, so that passengers on leaving the boats will pass through the second story of the ferry-house and cross West Street on bridges before descending to the street level.

The expense of this elevation of the road is considerably increased from the fact that it was necessary to build the new structure without interfering with the running of trains upon the old, the plan adopted being to build half the structure at a time, so that two tracks can be used before the old tracks are removed. Much of the structure also has to be founded upon piles, as for some distance back from the water front the ground has been filled in and does not give a solid foundation. At the ferry, for instance, water was found 6 ft. below the surface, and it was necessary to use piles 50 ft. in length.

The change will be a great improvement both for the railroad and the city, as it will obviate the inconvenience heretofore caused by the constant passage of trains across some of the principal streets. In making the improvement it was necessary to secure the consent of the city to the closing of one street, but all the rest will be crossed by bridges, and will be free from gates or other obstructions.

CONSIDERABLE attention has recently been drawn abroad to the Servé ribbed boiler tube, a French invention which was described and illustrated in the JOURNAL for May, 1887, at which time some remarkable figures were given showing the increase in heating surface obtained by these devices. At a recent trial made at the Atlas Steel Works, Sheffield, England, two boilers of exactly the same dimensions were tried, one fitted with ordinary tubes and the other with ribbed tubes, both being kept at the same pressure and run under similar conditions. The trials averaged in length from 3 to 12 hours, and the results show an economy in fuel of from 14 to 16 per cent. in favor of the ribbed tube. On one 12-hour trial the results show for the boiler with the Servé tube 11.03 lbs. of water evaporated per pound of coal against 9.50 lbs. for the boiler with plain tubes. The Servé tube has been used in a set of boilers just completed in Glasgow for a steamer, and will receive the severe test of a voyage to Hong-Kong and return. In France this ribbed tube has been adopted for several steamers, and the Paris, Lyons & Mediterranean Company has decided to introduce them on 40 of its locomotives.

THE city of Memphis, Tenn., formerly noted for its bad sanitary condition, has been improved in an extraordinary degree, partly by an improved system of sewerage, but chiefly by a supply of pure water. The city water was formerly drawn from wells and cisterns and later from Wolf River, but in both cases the surface water which yielded the supply was of very poor quality and contained many impurities, making it unfit for use and a constant cause of disease. Recourse was at last had to artesian wells, and it was found that at a depth of about 350 ft. there was a stratum of water-bearing gravel, the water being of exceptional purity, and abundant in quantity.

The city supply is now drawn entirely from these wells, and the works present many points of interest. The water-works draw their supply from 32 deep wells, which discharge into a tunnel, an arrangement adopted to prevent any influx of surface water. This tunnel is about 3,000 ft. long, is lined with brick and conducts the water

to a large well at the pumping works, from which it is pumped up and into the supply pipes.

The quantity of water is abundant for all present needs, and it is believed that any future increase in requirements can be met by increasing the number of wells. The geological formation of the country indicates that the water-bearing gravel is supplied from the hills of Middle Tennessee, where the rainfall is free from contamination, while the water is further subjected to a filtering process by the gravel through which it works its way.

THERE seems to be an especial field for the application of electricity in mining, where it is of great importance to be able to apply power without interfering with the supply of air. Hence the electric motor presents great advantages for hauling in mines, for operating drills and other machinery, running ventilating fans and similar purposes.

Electrical engineers have realized this, and have already paid much attention to the subject, with excellent results. This was seen at the recent meetings of the American Institute of Mining Engineers, and the British Iron & Steel Institute, at which several papers of much interest on electrical work in mines were read.

Others papers presented at the same time covered what may be called the purely metallurgical applications of electricity, such as electrical welding, separation of ores and other similar matters.

THE Ohio & Mississippi is one of the few railroads which can show an increase in average freight rates in recent years. For nine years past the average rate has been, in cents per ton-mile :

Year.	*Cents.*	*Year.*	*Cents.*	*Year.*	*Cents.*
1881–82	1.17	1884–85	0.81	1887–88	0.76
1882–83	1.00	1885–86	0.70	1888–89	0.81
1883–84	1.05	1886–87	0.72	1889–90	0.85

It will be seen that there has been a gradual increase for four years past, and that the rate last year showed a gain of 21¼ per cent. over 1885–86, the lowest year. Last year's rate, however, still showed a decrease of 30 per cent. from that of 1881–82. The cause of this unusual gain is to be looked for chiefly in the increased proportion of local freight.

THE same complaint is heard in England that has more than once been made by our own Navy Department, and that is the difficulty of securing proper and competent men for the engineering department, especially in the lower grades. It is more felt abroad than here, chiefly on account of the greater number of vessels and consequently of men needed. Our own Navy has many well trained and thoroughly educated engineers in the higher grades, but engine-room artificers and mechanics are not to be found when nor in such numbers as are wanted.

One great cause doubtless is that competent men can earn as much or more ashore, where they are free from the restraints of naval discipline ; but another certainly is that sufficient inducements in point of rank and standing are not offered. The traditions of naval service are long-lived, and the subordination of the engineering staff to the sailor and the fighting man in the naval organization is almost as complete as in the days of the old sailing frigate and line-of-battle ship. But the modern war-ship is essentially an engineering structure, and one of so complicated a description that its successful management depends almost wholly on the engineering staff. When this is realized and a proper place accorded the engineer and his subordinates, the greater part of the trouble now existing will pass away.

A GREAT dam is to be built across the Colorado River near Austin, Tex. This dam will be 1,150 ft. long, extending from bluff to bluff, and 60 ft. high from foundation to crest. It will create an artificial lake some 30 miles long, principally by deepening the river which for some miles above the site chosen flows between high bluffs. The canal through which the water will be drawn to furnish power will start from a gate-house at one end of the dam and will extend about 1,000 ft. through solid rock. The reservoir will be drawn upon to furnish water for the city and also to supply the power for pumping this water and for supplying electric light, and it is expected that there will be a large surplus of power which can be furnished to manufacturing establishments which could be located on the power canal or its extensions. It might be added that here would be an excellent opportunity for testing again the electric transmission of power. Large dynamos erected at or near the dam could furnish power to any part of the city or its vicinity.

AN elevated railroad is proposed for Boston by the West End Company, which owns all the street railroads of the city. The plan provides for a line which will use some of the existing street and other places run through private property. The first section would extend from Roxbury through the central portion of Boston to Charlestown, and would be about five miles long. An extension or branch to South Boston would follow the construction of the first line. The road would be run by electricity in all probability, although details have not been worked out. The Company asks for some assistance from the city in securing property needed, and while the plans are under consideration no action will be taken on them for some time. There seems to be, however, a general opinion that an elevated road of some kind in Boston is a necessity.

RECENT floods in the Moldau River in Bohemia have partly demolished one of the oldest bridges in the world. This was the famous Karlsbrücke at Prague, the building of which was begun in 1357, though it was not completed in its present—or late—form until 1507. It was 1,620 ft. long, having 16 stone arches resting on ponderous piers, and was a very fine specimen of mediæval masonry. The floods undermined the piers in the center of the river, and finally three arches of the bridge fell, after successfully resisting the storms and floods of 380 years.

THE next International Geographical Congress, it is announced, will be held at Berne, Switzerland, in August, 1891. The Berne Geographical Society has undertaken the local arrangements and entertainment of the Congress. It is probable that this meeting will be of especial interest to American geographers.

AN interesting part of the work of the Coast Survey has been the location of the frontier line between Alaska and the British possessions. Two parties have been at work on the Porcupine and Upper Yukon rivers for two sum-

mers past, but the work has been necessarily slow, as there are many difficulties to contend with: the remoteness of the region, difficulties in obtaining supplies, shortness of the season in which work is possible at all, and—last summer especially—a very rainy season.

ON November 1, according to the tables of the *American Manufacturer*, there were in blast 342 furnaces with a weekly capacity of 180,455 tons, an increase of five furnaces and 3,672 tons capacity over October 1. As compared with November 1, 1889, the increase is 13 furnaces in blast and 17,738 tons weekly capacity. Thus the production of pig-iron continues very active and there is little doubt that the year 1889 will show a greater production than that of any previous year.

A REPORT comes from Siam by way of Burmah that the contract for the first Siamese Railroad, to which reference has heretofore been made in our columns, has been let to a German firm, and that the road will be built of German materials and stocked with German rolling stock. Some doubt seems to be attached to this, however, and further advices are needed to confirm it. In Oriental countries such matters move very slowly.

WATER SUPPLY IN NORTHERN NEW JERSEY.

FOR some years past a corporation known as the East Jersey Water Company has been engaged, either directly or through subsidiary corporations, in securing control of the water and water-rights in Northern New Jersey, which could be made tributary to its plans. The Company has also secured, it is understood, the co-operation of the Lehigh Valley Railroad Company, which is lessee of the Morris Canal, a corporation chartered many years ago, and owning valuable water-rights and rights of way through the section named. The object of the Company was to secure control of the water supply which, it was foreseen, would be needed for the rapidly growing towns and cities in that section of New Jersey which is adjacent to New York, and those plans have already begun to bear fruit. The first important contract made has been with the city of Newark, which has drawn its supply for a number of years from the Lower Passaic, but has, especially of late years, found that supply unsatisfactory, owing to the constantly increasing impurity of the water inevitable in a river running with a moderate current through a densely populated region, where many factories add their share to the household refuse which passes in the river. The supply which is to be furnished to the city will be drawn from the tributaries of the Upper Passaic, which drain a large water-shed in a mountainous and thinly settled country, where there can be very little pollution of the water, and where, moreover, the rivers are rapid mountain streams which quickly purify themselves of anything which they receive.

The Newark contract was originally made with the Lehigh Valley Company as lessee of the Morris Canal, but was assigned to the East Jersey Water Company, which has undertaken the task of laying the pipe and providing the necessary storage reservoirs. The contract is for a supply of 27,500,000 gals. per day. The pipe line will be about 30 miles in length, starting from a point on the Pequannock River about 850 ft. above sea-level. The aqueduct will be made of steel pipe, which is now being laid. It was at first proposed to use the Morris Canal as an open conduit, but that plan has been abandoned in favor of the pipe system. The line commences not far from Oak Ridge, and follows nearly the lines of the New York, Susquehanna & Western and the New York & Greenwood Lake railroads to the distributing reservoirs above Newark.

In order to secure a regular and satisfactory supply, the Company has begun the construction of three large dams and reservoirs, in which will be stored the flow of the Pequannock and its tributaries. The first of these dams will be located near Oak Ridge, and will convert the northern end of the Longwood Valley into an artificial lake, having a capacity of 2,500,000,000 gals. The dam will be 650 ft. long, 45 ft. high, 500 ft. thick at the base and 20 ft. at the top, and will be built of earth, with a concrete core some 16 ft. thick. This will receive the flow of the Pequannock and its upper tributaries, drawing the water from the watershed of the eastern slope of the Wallkill and Canisteer Mountains.

The second dam, which is not far from the village of Newfoundland, will be of about the same cross-section as the Oak Ridge dam, but will be 1,500 ft. in length, and the artificial lake here formed will have a storage capacity of 3,538,000,000 gals., and in this will be gathered the water from the more northern slope of the mountains, and of one of two important tributary streams.

The third dam, which will be four miles southeast of the second, will be placed at the outlet of Lake Macopin, and will be of masonry 25 ft. high, 15 ft. thick at the base and 8 ft. at the top, and 400 ft. long. It will increase the present size of the lake by filling the valley in which it lies, and this will be used rather as a distributing reservoir than for storing great quantities of water, as its capacity will be not much more than 160,000,000 gals. From this point water will be drawn for the pipe lines.

The Company's plans are not limited to the supply of Newark, but arrangements are already being made to introduce the water into Jersey City and Bayonne, which have heretofore drawn their supply from the Passaic and, like Newark, have found it very unsatisfactory. In fact, it is proposed eventually to supply all the towns and cities between the eastern slope of the Orange Mountain and the Hudson River, a district which contains not only several large manufacturing cities, but also a great number of rapidly growing towns and villages, and which, it is estimated, will contain a population of probably about 1,000,000 within a comparatively short period. With proper arrangements for storage and distribution there seems to be no reason why the varied and extensive watershed of the Upper Passaic and its tributaries will not supply this population.

GERMAN WATER-WAYS.

THERE is no country in Europe which has made so much progress during recent years in the improvement of its internal water-ways as Germany. This is partly the result of the consolidation of government which took place some 20 years ago, but is more especially due to the efforts of the "Navigation Unions" which have been formed in a number of the principal cities with a leading

organization at Berlin. Their active and intelligent efforts secured the attention of the Government and have been continually devoted to interesting not only the Government, but the commercial bodies of the different cities.

The canal system of Germany is less extensive and perhaps less improved than that of France, but the length of navigable rivers is greater. So far the work done in recent years has been principally in improving the navigation of the rivers, and in providing port facilities at the commercial towns. Among the works so carried on are included the canalization of the Upper Oder; the canal connecting the Oder and the Spree; the canal from the Elbe to the Trave, and the canalization of the Maine from Frankfort to Mainz. The Oder-Spree Canal is not yet completed, but the work is well advanced, and work is also in progress on the ship canal which is to connect the North Sea with the Baltic. The last named, however, is principally a military work, which was undertaken with the primary object of connecting the two great arsenals and navy-yards at Kiel and Wilhelmshafn, although it will probably be of considerable service to commerce.

Among other projects which are now being pressed are the canal connecting Strasburg with the Rhine, the canalization of the Moselle and the canals from Magdeburg to the Elbe and from Dortmund to Emden.

All these works are being carried out by the Government, but while it provides a free water-way, the work of establishing ports and landings at the various commercial towns is left to local and private enterprise. At Hamburg, at Frankfort, and at other towns such works have been carried out on a great scale, and extensive basins and docks with complete facilities for loading and unloading have been provided. The effect of these works is evident in a very great increase of internal commerce on the various rivers, and in the beneficial results which the cheap transportation provided for coal, iron ore, and other freights have had upon the manufacturing industries. The railroads and the canals alike being under strict Government control in Germany, there has been no injurious competition for traffic, and it is claimed that the improvement of the navigation has in fact benefited rather than injured the railroads.

No transit tolls are charged on any of the German canals. The business of towing, however, is largely in the hands of companies, but is so conducted that the boats are able to carry freight at extremely low rates. Some of these boats belong to private owners, but a great many of them to the towing and transportation companies, and the system is found to work very well. The system of cable towage is in use for a long distance on the Elbe and in some other places, but its use does not seem to be extending, and on the smaller rivers and canals, where steam-tugs cannot be used, animal power seems to be still the main reliance.

THE ARCHITECT AND THE ENGINEER.

In England recently a noted writer made a violent attack on the Forth Bridge and its builders on account of the total lack of beauty in the structure; and later an American writer, in the *Popular Science Monthly*, criticised our architects severely because they are too much inclined to design buildings which are merely pretty, without regard to the use to which they are to be put, and to sacrifice the best design to outside show and ornament. Both have some reason in their comments, but the English critic the least. Mr. Morris is a poet and writer, and it seems impossible for him to take the engineer's view of the case. A structure like the Forth Bridge must be designed, first of all, with a view to its use as a bridge, and questions of taste or beauty find small chance for consideration. At worst it may be said of it, from an æsthetic point of view, that it is at least honest; it does not pretend to be anything else, and no feature of its proper use is sacrificed to ornament or merely pictorial effect. It may be imposing in its effect from its great size—as the Forth Bridge is—and in that case any attempt at ornament would weaken and impair the general effect. A bridge, although plainly and manifestly a bridge, as it should be, may nevertheless be far from marring the landscape, as Mr. Morris charges that the Forth Bridge does; the Poughkeepsie Bridge, for instance, as seen from the river below, is certainly a graceful structure, and really seems to harmonize with the natural surroundings, while the Brooklyn Bridge can hardly be called ugly or ungraceful.

On the other hand, Mr. Ferree's indictment against the architects has some counts which are not easy to disprove. There is a tendency to mere prettiness; there is a disposition to make buildings which will look well, without regard to the use to which they will be put. A Gothic window, an elaborately ornamented Byzantine or Renaissance doorway, are admirable in their proper places; but the architect who leads the passer to think that his building is a church when it is really a bank, the office of a machine shop, or a railroad station, is not to be commended, and that is not true art which builds the tower or stand-pipe of some city water works in imitation of an Italian *campanile*. Moreover, it is true in more than one notable case—and it is not necessary to go outside of New York or Chicago to find them—the real constructive strength of a great building has been sacrificed to appearances or to mere show, not deliberately perhaps, but really through ignorance and because the architect's training had led him to neglect the engineering side of his profession.

The fact is that here, as in many other cases, it is not easy to draw an exact line of demarcation between the two professions. It has been said that the engineer should be something of an architect; it may also be said that the modern architect should be a good deal of an engineer. The great size of some of our buildings and the amount of machinery needed to run them properly bring up questions which require no small amount of engineering skill to solve. The foundations of the Produce Exchange in New York, for instance, were nearly as difficult a work as those of the Brooklyn Bridge piers, and many similar cases could be cited; and an error in one would be about as costly and as troublesome in its consequences as in the other.

Our modern requirements are so extensive, however, and the range of knowledge to be covered is so great, that it is probably asking too much to expect a single man to master two professions; and while the architect should understand the fundamental principles of engineering, in all important structures an engineer ought to be called on to decide all special points and to assist the designer with his skill and experience. On the other side, the engineer should not be above asking the assistance of the architect, and considering, to as great an extent as possible, the outside appearance and general effect of his work.

In this way the balance may be preserved, and the result will be that our great buildings will not show either structural weakness or useless waste of material, and our railroad shops and other structures will not be distinguished by bare ugliness and a general lack of all appearance of design. Perfection is not to be expected in human work, but some improvement over much of our present work may be hoped for.

THE TENNESSEE RIVER IMPROVEMENTS.

An important work now approaching completion is the canal which will enable steamboats to pass the obstructions known as the Mussel Shoals, and will complete the connection between the navigation on the upper and the lower Tennessee. This canal, which was first projected more than 60 years ago, was actually begun in 1875, and has been executed as rapidly as the appropriations made by Congress from year to year would permit, the work having been undertaken by the United States Government.

The Mussel Shoals proper, with the Little Mussel Shoals below them, are a series of rocky barriers or obstructions some 30 miles in length, which have prevented all navigation of the Tennessee River for a distance of over 40 miles. The whole improvement includes a canal 1½ miles in length, with two locks, around the upper end of the barrier—known as the Elk River Shoals; the clearing out of the river channel for four miles above that canal and for eight miles, from the foot of the Elk River Shoals to the head of the Mussel Shoals proper; a canal 14½ miles long, with nine locks, around those shoals; and finally the cutting of a channel at the Little Mussel Shoals, 2½ miles long, through rock, with wing dams to regulate the current and preserve the channel.

The locks, which are 11 in number, as stated above, are all 300 ft. long and 60 ft. wide, and overcome a total fall of 134 ft. The canal has a uniform depth of 6 ft., its width varying from 70 to 120 ft., and is intended to pass steamboats of 5 ft. draft at any stage of the river. It has been built with great care, all precautions having been adopted to prevent damage by flood, and to avoid any interruption to navigation.

The most important structure on the canal is the viaduct which carries it over the mouth of Shoal Creek, not far from the foot of the canal. This viaduct is 860 ft. long, and is substantially a trough 60 ft. wide and 6 ft. deep, of steel plates, carried by steel girders, which are supported by abutments and 25 piers of masonry. There are thus 26 spans, averaging 30 ft.; 21 girders in each span carry the weight of the aqueduct.

The canal is now very nearly ready for the passage of boats; but to make it fully available it will be necessary to complete the channel at Colbert Shoals and Bee-tree Shoals, 21 and 25 miles below. At each of these a lock and dam are to be built and the channel cleared out. The dams will serve to keep a depth of at least 5 ft. in the channel in the dry season, and will finally open the navigation of the river from Knoxville in East Tennessee to the Ohio River.

The importance of this improvement will be seen when it is remembered that the Upper Tennessee and its tributaries flow through the coal fields and rich mineral regions of East Tennessee, and that barges loaded at Knoxville or Chattanooga will be able to carry their freight through without transfer to Memphis, Vicksburg or New Orleans. Having its sources in an extensive mountain and forest region, the Tennessee has a fuller and more uniform water supply than the Upper Ohio; and with the industrial growth of the region through which it flows, will doubtless become an equally great and important highway of commerce.

ENGLISH AND AMERICAN LOCOMOTIVES.

Our distinguished English contemporary, the *Engineer* of November 7, contains another article on this subject, which is made up largely of data concerning the performance of English locomotives, the burden of which is to show that they evaporate more water per pound of coal than American locomotives do. There is not time before the December number of the Journal goes to press to analyze the figures it gives, nor to compare them with those representing the performance of American locomotives. For the present, then, the only comment we will make is that as a question of economy, of locomotive performance, the rate of evaporation is only one of the elements. As we have pointed out before, a locomotive may show a high rate of evaporation, and at the same time the cost of locomotive service may also be high in proportion to the amount of work done. We may have something to say on this branch of the subject, and also on the rate of evaporation in American locomotives under different conditions hereafter.

Our contemporary is silent about the rate at which coal can be burned in English locomotives compared with that which we have shown repeatedly in common practice in American engines. Its only reference to this branch of the subject is a statement that, in some experiments made by Mr. Drummond, of the North British Railway, thirteen years ago, in which he burned 83 lbs. of coal per square foot of grate per hour. This is the highest rate of combustion that our contemporary has claimed for English locomotives. In a preceding number it said "about 75 lbs. may be regarded as our maximum." The rate of evaporation in American locomotives, as given by well authenticated reports quoted in these pages, is 119.3, 121.6, 133.2, 148.1, and 193.7 lbs. of coal per square foot of grate per hour. The *Engineer* says nothing about these figures. The facts which they represent certainly have an important bearing on the question under discussion.

As *Engineering News*, which originally entered into this discussion with much ardor, has announced that he or it "will not play any more," either we must change our position as an independent commentator, or the discussion must come to an end. Undoubtedly much will be lost to the world by the decision which the editor of the *News* has announced. Perhaps more truth will be evolved in a discussion of this kind, if one of the parties to it assumes the attitude of an engineering agnostic than if he is confident that truth and rightness is altogether and exclusively on his side.

The *Engineer* complains that the American technical press has not handled this important and interesting question with sufficient seriousness. In the language of Pope, slightly changed, it may be said of our contemporary:

> "Great was the cause; his old *solemnities*
> From no blind zeal or fond tradition rise."

It was, perhaps, thoughtless to joke on such an occasion.

It is said to be a flagrant breach of the code of true politeness to make use of words from a language which the person addressed does not understand. It is, perhaps, equally inconsiderate to discuss important subjects in a sportive way with those who are inclined to consider them solemnly. We will try to be very serious in discussing this subject hereafter.

THE LAUNCH OF THE "MAINE."

THE launch of the armored cruiser *Maine* at the New York Navy Yard, on November 18, attracted much public attention, and was witnessed not only by some of the chief officials of the Navy and the Army, as specially invited guests, but also by one of the largest assemblies of sightseers that has been gathered about New York for a long time, including many well-known persons. Reference has been made to the *Maine* from time to time in our columns, and a brief description of the ship will be found on another page. The launch, it may be noted, was successful in every respect.

The launch of the *Maine* really deserved some attention, since it was in two ways a notable event. The vessels which have been completed thus far for the Navy are all of the unarmored cruiser type, swift ships, which can be made very useful in time of war, and which are excellent representatives of the country abroad in time of peace, but which are not adapted for heavy fighting or close quarters with an enemy's fleet. The *Maine* and the battle-ship *Texas*, which is now under construction at Norfolk, were the first fighting ships of modern design undertaken, and will be when completed the first ships in the Navy protected by heavy armor and carrying batteries which can be used with some chance of success against an armored antagonist. Moreover, the *Maine* and the *Texas* are the first steel ships of the new types to be built in the Government yards, and their construction is a test of the capacity of those yards for adaptation to modern plans and methods—a test which has so far shown excellent results.

The *Maine* is not by any means completed yet, as she has still to receive her engines and boilers, the side armor belt, the barbette armor, turrets, and masts; it will, in fact, be a year in all probability before she is ready to receive her armament and go into commission. Much of the work, especially that on the engines and boilers, is done, however, and there will be no delay in pushing the work forward.

The battle-ship *Texas* at the Norfolk yard, while not yet ready for launching, is making steady progress, and will not be much behind the *Maine* in getting ready for sea. By the time they are in commission the three battle-ships for which contracts were lately let will be well under way.

EDITORIAL NOTES IN PHILADELPHIA.

THERE is no place in the country in which a mechanical engineer will find so much to interest him as he will in this sober city on the Delaware. Manufacturing is there regarded as the most important interest in the community, and the most influential people are manufacturers, among whom the mechanical engineers take the lead. A visit to Philadelphia is therefore always interesting, and the following notes are intended as a sort of reflection of what was seen and heard there during a recent hasty visit to several of the large establishments for which that city is noted.

The first landing, so to speak, was made at the works of Bement, Miles & Company, the well-known makers of machine tools. This firm is making important extensions to its establishment, the buildings for which are now nearly completed, and when fully equipped will add very materially to its capacity for turning out work.

Before the present extension was made, the shops occupied about three-quarters of the block bounded by Callowhill, Twentieth, Twenty-first streets and Pennsylvania Avenue, shown in the plan, fig. 1. The remainder or eastern end, indicated generally by the area *A B C D E F*, was occupied by dwelling-houses, a coal-yard, etc. The buildings on this ground were pulled down, and the new extension of the works has been built in their place. This portion of the extension, as shown, is generally of an ┘ form; the lower side of the ┘ having 160 ft. on Callowhill Street, and the right-hand side 193 ft. on Twentieth Street. The building on this area is three stories high, and has what may be called two grand halls, which are open to the roof, and each has a Seller's traveling crane of 60 ft. span, 30 tons capacity, and 35 ft. lift. On the Callowhill Street side of the grand hall, *H*, are two galleries 24 ft. wide and on the Twentieth Street side of *G* two more, each 30 ft. wide—three stories in all—which are occupied by tools and machinery. These galleries are served by the cranes, and as they are connected with the foundry, as will be explained, and also with a railroad track and the packing department at the north or Pennsylvania Avenue end of *G*, they give the best of facilities for handling heavy and also comparatively light work. On the north side of *G* the boilers and engine are located, and above them are galleries similar to those on Twentieth Street. The tool and fixture-room is on the third story gallery, and is 30 × 105 ft. A drying-room for lumber is located over the boilers. These are new, of the Wharton-Harrison type of 400 H.P. The power will be supplied by a new compound high-pressure engine of 200 H.P., built by McIntosh, Seymour & Company, of Auburn, N. Y.

The new extension is all fire-proof, or of "slow burning" construction, and is admirably lighted from skylights of the "saw-tooth" form, in which the windows have only a northern exposure. It is remarkable how slowly those who have charge of the erection of new shops are in recognizing the advantages of a north light, as it excludes the sun, and the light is constant at all times of the day. The windows in the street sides of the buildings are ample in size, the walls on the inside next to the windows being flared, which increases very materially the amount of light admitted by them. It is singular, too, how slowly the advantages of this feature are in being recognized by those who build shops and houses. The shops will be equipped with a complete Edison electric plant for lighting. Three Otis elevators or lifts, not shown on the plan, will communicate with and serve the different galleries and stories in both the old and the new portions of the shops.

The long, narrow space indicated by *L* and extending from *J* to *K* was formerly a drive-way, and was bounded on the south side by the wall of the old machine-shop *M*. This wall has been taken down and the space roofed over, and two 20-ton Yale & Towne cranes of 50 ft. span have been erected in this space, and have a run of 210 ft. The old machine-shop is three stories high. By the removal of the north wall the different floors became galleries, which are served by the cranes in *L*. As the foundry is on the north side of *L*, these cranes give excellent facilities for handling castings and carrying them to any of the floors of the machine-shop, and thence to the erecting floors *H* and *G*. It is the intention ultimately to put in another pair of cranes alongside of those in *L*, and narrow the floors in *M* to the same width of the galleries on the Callowhill side of *H*.

A new building, 85 × 65 ft. and three stories high, indicated by *I* in the plan, has been erected on Pennsylvania Avenue adjoining the foundry, and between it and the new extension. The lower story of this will be used as a cleaning-room for castings, and is fitted with pickle tubs, cranes, etc. The second story will be used as a storeroom for finished tools and machinery, and the third as an extension of the pattern-shop.

N is the core-room, and *O* the core ovens. It will be seen that the cores can be put into the ovens from one side and delivered into the foundry on the other.

P is a large pattern storehouse built a few years ago, and is 190 × 40 ft. It is three stories high, entirely fire-proof, and connects with the foundry by a large door from which the patterns can be handled by the foundry cranes.

Besides the shops which have been described, this firm are also using the old Machine Tool Works at the corner of Twenty-fourth and Wood streets, in which they build hydraulic and steam machinery and other heavy work. From 750 to 800 men are employed in both the shops, and when the extension is completed about 100 more men may be employed. The new extension and plan will improve very much the facilities of the firm for handling all their work, but especially the heavy machinery which is now required by the Government and other large establishments.

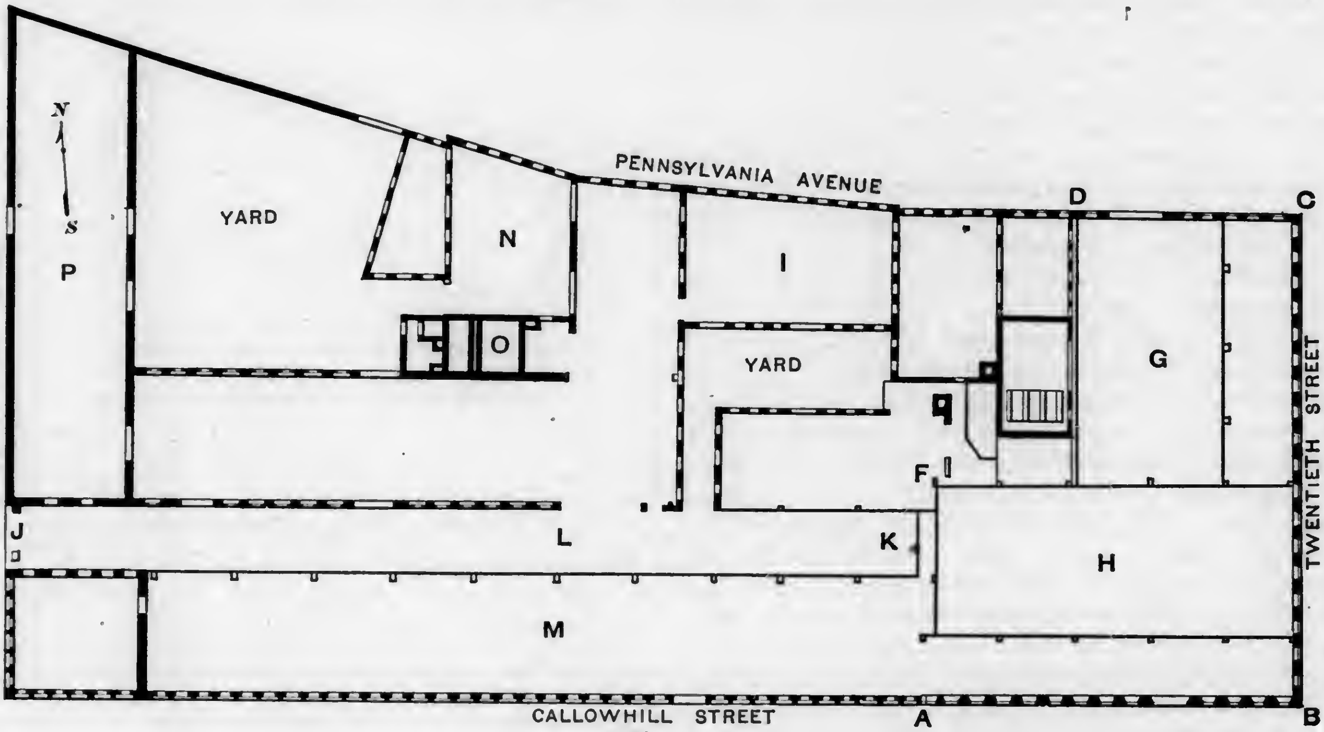


Fig. 1.

PLAN OF SHOPS OF BEMENT, MILES & COMPANY, PHILADELPHIA.

WILLIAM SELLERS & COMPANY.

This firm has also added materially to its facilities for doing work. An extension 60 × 140 ft., with a 30-ton traveling crane, which lifts 32 ft. and is driven by an electric motor, has been built about a year. A second extension is now being built west of this and parallel to it. This will be 60 × 200 ft. Some of the old portions of the shop are to be removed to make room for it. It will also have a traveling crane for handling heavy work. It will have a span of 57 ft. and a capacity of 50 tons, and will lift 40 ft. A new floor is also being put into the erecting shop corner of Pennsylvania Avenue and Seventeenth Street, making two stories to the building. These extensions are being added to their works to enable them to complete large contracts for heavy work for the Government.

PEDRICK & AYER.

This firm has moved into the new shop on Hamilton Street within the past year. It is a four-story building 40 × 160 ft., with the boilers and dynamos in the basement. They are making a specialty of what they call their open-side planing and shaping machine, which is the invention of John Richards, of San Francisco, and has been improved by Mr. Edward A. Walker, in the employ of Messrs. Pedrick & Ayer. The peculiarity of this machine is that the work or the part to be planed stands still and the tool-holder moves. Consequently the weight of the piece to be planed is a matter of no importance in doing the work, as it stands still while the head carrying the tool does the work. They are building these of various sizes, the largest being 40 ft. long. They have furnished these planers to the Russian and German governments, to Sir William Armstrong's Elswick works in Newcastle, England, and about 20 are in use in this country.

They also make a specialty of a heavy universal milling machine. Their new pattern takes work 30 × 12 in. wide. They have recently shipped the sixty-eighth of these machines.

A cheap model of link-motion, to illustrate the principles and working of valve-gear to students, firemen, etc., has also been added to the list of machines they manufacture.

Their new shop is admirably arranged with excellent light, and gives them greatly increased facilities for doing work.

BALDWIN LOCOMOTIVE WORKS.

Very extensive alterations and additions to this establishment are also in progress, and part of them are completed, and are shown in the perspective view, fig. 2, which represents the buildings on the block bounded by Broad, Spring Garden, Fifteenth and Buttonwood streets. The office is at the right-hand corner at *A*, and extends to *B*. *B C D* is a new four-story shop, the plan of which is of the form of a letter L. This is completed and, as shown by the engraving, is four stories high, and is used for doing the work—such as fitting and bending pipes, polishing connecting-rods, sheet-iron work, etc.—which is incidental to the erection of locomotives. This building fronts from *D* to *C* 208 ft. on Fifteenth Street, and from *C* to *B* 228 ft. on Spring Garden. It is 60 ft. wide on Fifteenth and 48 ft. on Spring Garden.

E F G H is the new erecting shop, 336¼ × 159 ft. It is divided lengthwise by a row of iron columns into two divisions or bays, as shown by fig. 3, which represents a cross-section of the building. Each division or bay has a 100-ton traveling crane built by Messrs. William Sellers & Company. The cranes have 74 ft. 8 in. span, measured from center to center of rails, and 28 ft. lift. Each crane has two trolleys of 50 tons capacity. The cranes will both be driven by electric motors. The purpose is to be

able to pick up the largest locomotive in any part of the shop and lift and move it to any other part with the same facility that a woman would transfer her baby from one part of the nursery to another. Although the engraving gives the building the appearance of having two stories, it is in reality open from the floor to the roof, so as to get sufficient height for handling locomotives and their different parts. This building when completed will be the finest erecting shop in the country, and probably in the world. The roof, as shown in the engravings, has skylights of the saw-tooth pattern, which admit light only on the north side and thus exclude sunshine, a method of construction which is very common in England, where they have little sunshine, but which has only recently been adopted here.

While in these shops an opportunity occurred of seeing the new method of turning tapered bolts, which has been devised by Mr. Vauclain, the Superintendent of the shops. The machine which is used for this purpose is a multiple spindle drill-press, with a very coarse feed ¼ to ⅝ in. to a revolution. Below each spindle is what may be called a die or a cast-iron block with a hole somewhat larger than the bolt. Located radially around this hole are four cutters or tools for the rough cut on the bolt. These tools have a long cutting face and are accurately ground for the purpose. The block and cutters are submerged in oil. The block or die for the finishing cut has only two cutters opposite each other, and between them are two V-shaped guides for steadying the bolt as it is being finished. This method of turning bolts promises to work a revolution in doing this kind of work. It is said that a boy will turn as many as 1,000 ⅞-in. bolts on one of these machines in a day. The work is better done than it would be on a lathe, and the taper and size of each bolt must be correct if the tools are properly maintained.

An interesting feature in connection with the Baldwin Locomotive Works is the restaurant, or rather what might be called the club rooms, which have been established in their works for the use of their workmen. To describe this we will be obliged to go back somewhat and say that, in Philadelphia, they have what they call the "Neighborhood Guild Association," the object and purpose of which is described as follows in one of the publications of the Guild:

The "Neighborhood Guild Association" was organized in December, 1887, by a number of citizens representing various religious denominations, professions, and callings, for the purpose of providing in different localities of the city better social and educational opportunities for the people of the neighborhood, including young and old of both sexes. Our organization and work are absolutely unsectarian. Any person by the payment of an annual fee of $5 may become a member of the Association and vote at the annual meeting. An executive committee of 12 persons is annually elected. Members of the Association are entitled to all the privileges of the Neighborhood Guild rooms.

The practical work of the Neighborhood Guild Association began at Pequa Hall, Twenty-third and Hamilton streets, early in 1888, with a series of Saturday evening entertainments, consisting of concerts, dramatic performances, lectures, etc. A house was soon rented at 2134 Vine Street, and a coffee-room, reading-room, and library were established; rooms were furnished for games, music, classes, etc.; and the basement was fitted up for manual training. During the first and second seasons classes were started in carpentering, wood-carving, drawing, clay-modeling, dress-making, cooking, and vocal music. Early in the present season classes were formed in political economy, history, literature, short-hand and vocal music; and courses of lectures on hygiene, economics, and popular scientific subjects were arranged. By the first of the present year it was found necessary to look for a house with larger accommodations.

The proprietors of the Baldwin Locomotive Works, hearing of this, and wishing to provide a restaurant where their men could obtain a good dinner at a reasonable price, made the following offer to the Neighborhood Guild Association:

"If," they said, "you will undertake the entire management of a restaurant that we propose to equip, running it without profit and using all gains to reduce prices and improve quality, we will compensate you by giving you, rent free, the use of the rooms over the restaurant, and furnishing electric light and steam-heat without charge."

This offer was promptly accepted, and on February 1 the Guild moved to its present commodious and pleasant quarters, southwest corner of Fifteenth and Spring Garden streets. On the second floor we have a large and well-appointed restaurant, at which good food at cost prices is furnished to the workingmen of the neighborhood. Over the restaurant we have an attractive and pleasant lecture-room, several class-rooms, and a reading-room. A room on the sixth floor, 30 × 120, recently placed at our disposal, is being fitted up as a gymnasium. Since coming into our new quarters the classes begun at the

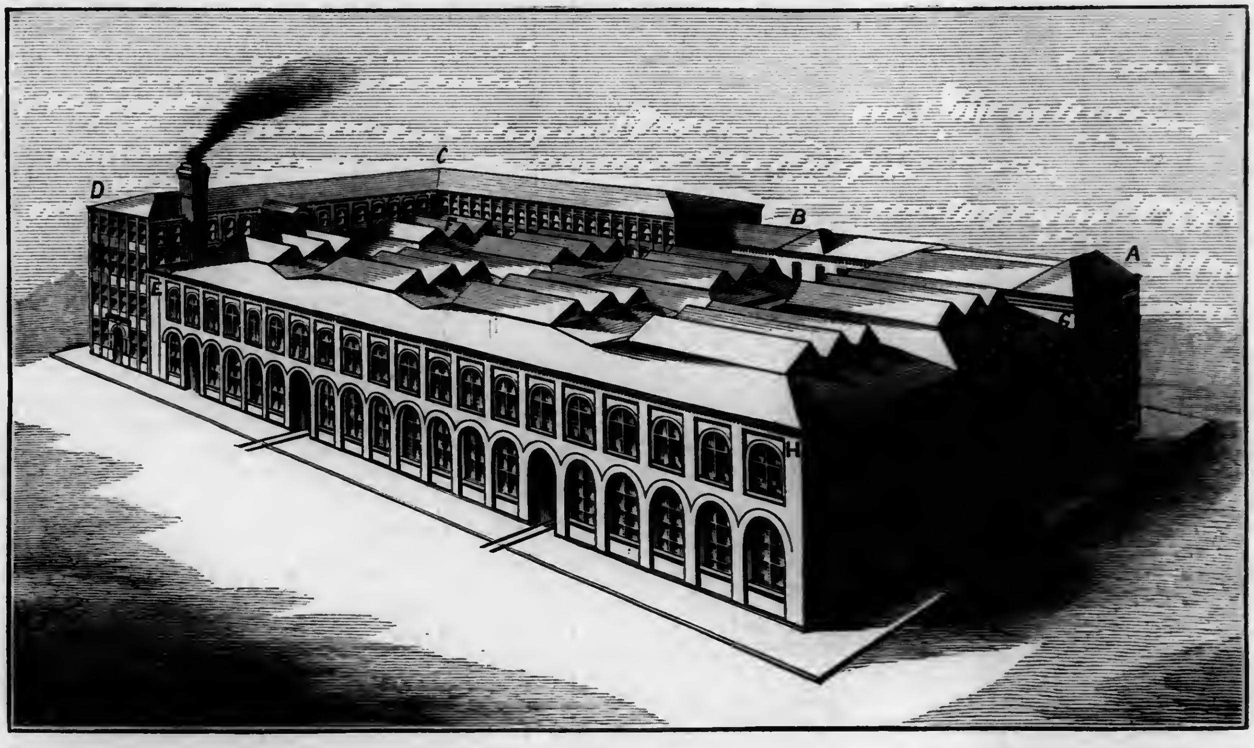


Fig. 2.

NEW SHOP OF THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA.

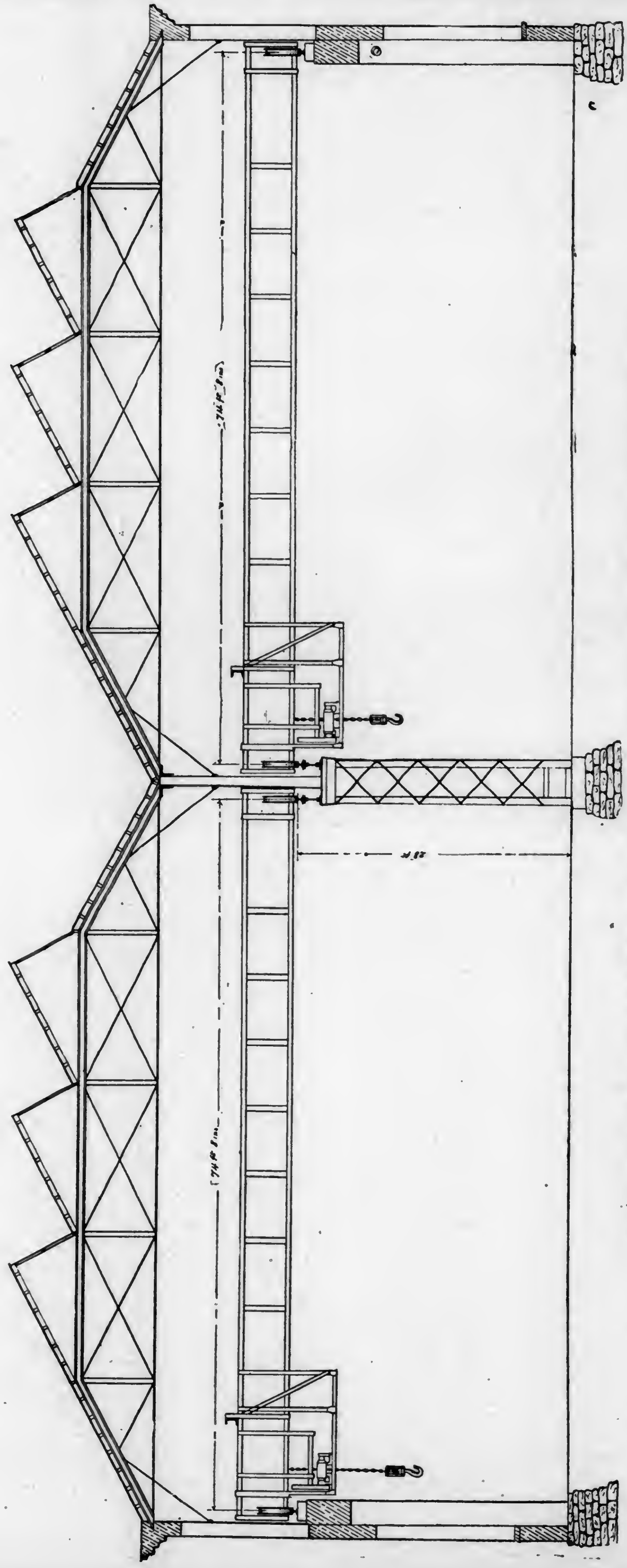


Fig. 3. CROSS-SECTION OF ERECTING SHOP, BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA.

Vine Street house have been continued, and in addition classes in physiology, penmanship, elocution, instrumental music, gymnastics, and military drill have been formed, besides classes in kindergarten, kitchen-garden, etc., for the children in the afternoon.

The rooms in the Baldwin Works are light, cheerful, and scrupulously clean, and are well patronized both at meal times and in the evenings. The bill of fare for the day, posted on the blackboard, when we visited the dining-room, was soup, roast beef, veal pot-pie, two vegetables, bread and butter, tea, coffee, or milk, all of which was supplied for 15 cents. The extras were: pie, 5 cents; pudding, 3 cents; floating island, 3 cents; bread and butter and coffee, 5 cents; tea or coffee, 3 cents; crackers and milk, 3 cents. The quantity of these different articles furnished is very liberal; the glasses, for example, in which coffee and milk are served, are in the form of a frustrum of a cone $3\frac{3}{8}$ in. diameter at the top and $2\frac{1}{8}$ in. at the bottom and 5 in. deep. We leave the problem of calculating its contents to some of our young mathematical readers.

The rooms and restaurant are under the charge of a matron, Miss V. M. Walker. Altogether it seems to be an admirable method of benefiting workingmen, and of showing that those who employ them have a fellow-feeling for them, and it might be imitated to advantage in many other similar establishments.

A locomotive-shop is not a place where one would expect to encounter romantic incidents, nevertheless it seems as though that phase of human experience follows mankind in all walks of life, and refuses to be eliminated from even the most prosaic occupations. The particular incident to which these remarks are introductory is the fact that the Baldwin Works have recently furnished some locomotives for the Jaffa & Jerusalem Railroad in Palestine. This is a meter-gauge road, which is being built from Jaffa—the ancient Joppa of the Bible—which is the port of Jerusalem. Fig. 4 is an engraving of one of the locomotives which has arrived in Jaffa, and has been put to work on the new Judean railroad. As the engraving shows, it is of the "mogul" type, which seems appropriate for a locomotive sent to the Orient. It has 15 × 18 in. cylinders, driving-wheels 41 in. diameter, and weighs 58,000 lbs. The Baldwin Works agent, who was sent over to put up the engine, has written the following interesting letter in relation thereto:

HOTEL JERUSALEM, JAFFA, October 3, 1890.

MESSRS. BURNHAM, PARRY, WILLIAMS & COMPANY:

GENTLEMEN: I am very glad to be able to report that we made a successful trial trip of the first engine (*Jaffa*) to-day. All Jaffa was out to see it, including the Turkish Governor and his court. It was estimated that at least 10,000 people were on the housetops and along the line of the road, and over two-thirds of them never saw a locomotive before. Many of the

Arab women moved their household effects along the line of the road several days ago, so as to be on hand when the great thing went along. Many flags were hoisted over public buildings in honor of the occasion. I got an American flag from the Consul and put it on the front bumper. The French engineer put two French flags on each corner of the cab, and we secured a Turkish one on the other corner of the bumper, and so we went up into the town. I doubt if any other engine built by the Works ever received so much attention as 8–24 D, and as for me, well, I never expected people to regard me as the Arabs did to-day and have been doing. They simply think that I have been cutting and carving it out of a lot of railroad iron and boxes. They have a great respect for the French engineers and think them very smart, but when it comes to making a machine such as they saw to-day, "they can't do it in France," "they had to send to America for a man to make it." The officers of the road were very much concerned about the engine getting through some of the sharp curves along the wall, and also the strength of the track; in fact, they offered to make any alteration I might want. I had examined the track carefully, and saw nothing that the engine was not able to take easily. Before starting they got some screw jacks, blocks, and other things, and were piling them up on the engine. I asked the superintendent what they were for, and he said to put her on the track if she got off. "All right," I said, "but we won't need them." We went over the short piece of road in good style and without a stop. She went fast enough also to keep the flags to the breeze, so that all would see what sort of flags they were. They were all very much pleased that no change had to be made, and that the engine curved so nicely. The machinery has all come right so far and without trouble. We expect to start on the second one tomorrow.

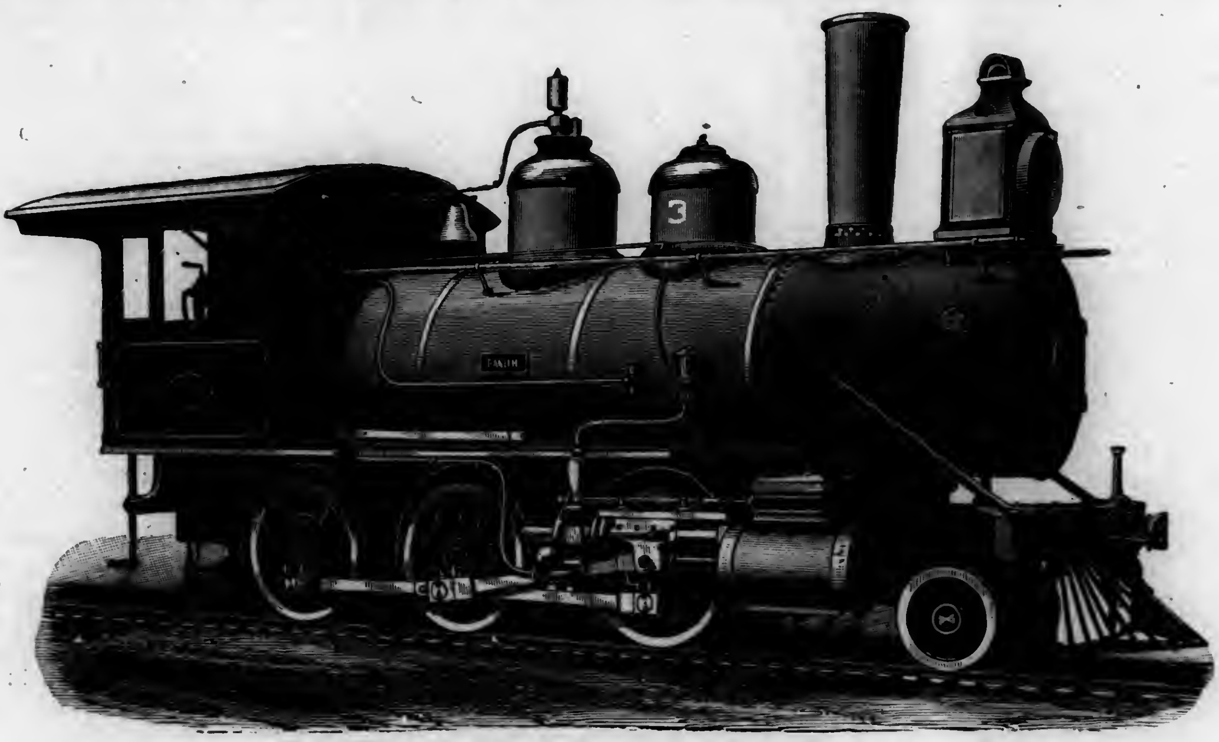
All the circumstances connected with the event of starting a locomotive in the land in which the principal events narrated in the Bible transpired recalls Hood's poem on

THE IMPUDENCE OF STEAM.

Over the billows and over the brine,
Over the water to Palestine !
Am I awake, or do I dream ?
Over the Ocean to Syria by steam !
My say is sooth, by this right hand ;
    A steamer brave
    Is on the wave,
Bound, positively, for the Holy Land !

  GODFREY of Bouillon, and thou,
  RICHARD, lion-hearted King,
Candidly inform us, now,
    Did you ever ?
    No you never
Could have fancied such a thing.
  Never such vociferations
  Entered your imaginations
As the ensuing—
    "Ease her, stop her !"
"Any gentleman for Joppa ?"
"'Mascus, 'Mascus ?" "Ticket, please, sir."
"Tyre or Sidon ?" "Stop her, ease her !"
"Jerusalem, 'lem ! 'lem !"—"Shur ! Shur !"
"Do you go on to Egypt, sir ?"
"Captain, is this the land of Pharaoh ?"
"Now look alive there ! Who's for Cairo ?"
"Back her !" "Stand clear, I say, old file !"
"What gent or lady's for the Nile,
  Or Pyramids ?" "Thebes ! Thebes ! sir !" "Steady !"
"Now, where's that party for Engedi ?"

Pilgrims holy, Red Cross Knights,
  Had you e'er the least idea,
Even in your wildest flights,
  Of a steam trip to Judea ?
What next marvel Time will show,
  It is difficult to say,
"Buss," perchance, to Jericho ;
  "Only sixpence all the way."
Cabs in Solyma may ply ;—
  —'Tis a not unlikely tale—
And from Dan the tourist hie
  Unto Beersheba by "rail."



MOGUL LOCOMOTIVE FOR THE JAFFA & JERUSALEM RAILROAD.

BUILT BY THE BALDW N LOCOMOTIVE WORKS, PHILADELPHIA.

The author of the letter from which we have quoted also sent several photographs showing views of part of Jaffa, with the narrow-gauge road along the edge of the waters of the Mediterranean, and the locomotive in the distance. From these photographs a person can select for himself which of the houses shown was the residence of "one Simon, a tanner whose house was by the seaside," and also the housetop on which Peter "fell into a trance." Without any irreverent intention, we may wonder what changes would have been made in Chapter X. of the Acts of the Apostles if the little narrow-gauge

locomotive could have been seen by Peter, together with "the four-footed beasts of the earth, and wild beasts, and creepings things and fowls of the air," which then appeared to him. The Good Book says he "doubted in himself"—would his doubts have been increased or diminished by seeing the chariot of fire which has worked such wonders in modern life, and probably will be, literally, the forerunner of great changes in the Holy Land?

ELECTRICITY IN DAILY LIFE.

Electricity in Daily Life: a Popular Account of the Applications of Electricity to Every-day Uses, by various Authors. New York; Charles Scribner's Sons. 288 pages, 125 illustrations; price, $3.00.

During the past ten years electricity has been put to so many practical uses, and has come to play so large a part in our every-day household and business life, that every educated man and woman, without being an expert, will naturally wish to have some general knowledge of the history and methods of its application. This want the Messrs. Scribner sought to supply by a series of articles published this year in their magazine, and the articles have now been collected in the book before us, which is in the same general style as the "American Railway," and forms an excellent companion to that handsome volume.

The various chapters have been written by experts, but are not obscured by too much technicality. Too few of us are really versed in the science of electricity to understand readily a profound or technical work on the subject; but we are all interested in a clear explanation of its workings and of the ways in which it has been applied for the transmission of power, for lighting and for the other purposes which it now daily serves.

Perhaps the scope of the book can best be explained by giving the headings of its chapters, which are as follows: Electricity in the Service of Man, by Professor C. F. Brackett; the Electric Motor and its Applications, by Franklin L. Pope; the Electric Railway of To-day, by Joseph Wetzler; Electricity in Lighting, by Professor Henry Morton; the Telegraph of To-day, by Charles L. Buckingham; the Making and Laying of a Cable, by Herbert Laws Webb; Electricity in Naval Warfare by Walter S. Hughes, U. S. N.; Electricity in Land Warfare, by John Millis, U. S. A.; Electricity in the Household, by A. E. Kennelly; Electricity in Relation to the Human Body, by M. Allen Starr, M.D.

The first chapter is a general introduction to the subject, which the others follow in detail, showing how electricity has been applied in manufacturing, in transportation, in lighting, in transmitting messages, in lightening household work, in medicine, and how it is proposed to use it in warfare, for so far, fortunately, there has been but little chance for its use in actual war. The telegraph is the oldest of these practical applications and the one with which we are most familiar, but even with respect to that and its later adjunct, the telephone, popular knowledge is still somewhat vague, and almost every one will read the chapter on that subject with interest. The various forms and applications of the electric motor are daily becoming more familiar, and the electric railroad is steadily making its way in our cities and towns, so that the electric car is no longer a curiosity, but a part of daily life and experience in so many places, that an explanation of the principles on which it is based cannot fail to command the attention of numerous readers. The same thing can be said of the electric light, but the application to the smaller household uses is still comparatively new, and should be carefully studied. The chapter on applications in medicine seeks to confute some false ideas which are current and to show the real and valuable uses to which electricity may be put in this direction, and to expose some quackery, the partial success of which has been based on popular ignorance.

The book is not a profound scientific treatise for the electrical engineer, but as a popular work it gives general views of the subject based upon sound scientific knowledge, and it is well worth attention, not only from the general reader, but also from the engineer, who, while not making electricity his specialty, wishes to know what has been done and upon what the advances made in that department have been based.

NEW PUBLICATIONS.

SECOND ANNUAL REPORT ON THE STATISTICS OF RAILROADS IN THE UNITED STATES TO THE INTERSTATE COMMERCE COMMISSION, FOR THE YEAR ENDING JUNE 30, 1889: HENRY C. ADAMS, STATISTICIAN TO THE COMMISSION. Washington; Government Printing Office.

Reference has frequently been made in these columns to the importance of securing uniform and official reports of the condition and operations of the railroads of the United States. An interest in which the investment is represented by $8,600,000,000 of securities, the yearly gross revenue of which amounts to nearly $965,000,000, and upon which the social life and economic conditions of the people generally are so closely dependent, is of too great importance to permit its operations to pass unnoted and unrecorded officially. The Interstate Commerce Commission has wisely exercised its authority in collecting these statistics, and they have been carefully and intelligently presented in Mr. Adams's report.

In collection much progress has been made since the first report was issued. According to the figures of the Commission there were 157,759 miles of railroad in the United States on June 30, 1889, and of this 149,949 miles were covered by the reports made to the Commission, leaving 7,810 miles not reported on. As nearly every line of any importance is concerned in interstate business and comes under the jurisdiction of the Commission, the unreported mileage is composed chiefly of short and unimportant lines, whose addition would not greatly affect the totals and averages obtained.

The mileage given above is of railroad; the total length of track was 200,950 miles, in operating and maintaining which there were used 29,036 locomotives, 25,665 passenger-train cars, 1,040,269 freight cars, and 31,657 service cars; while in the service of the roads 704,743 persons were directly employed. To these should properly be added those at work in factories supplying railroad material, but there is no way of ascertaining the number of that class. With the amount of material to work upon, it is not to be wondered at that the report makes a volume of 566 pages.

The Statistician recognizes fully the importance and the difficulties of the work imposed upon him. While admitting that the railroad companies in most cases have readily complied with requirements, and have co-operated with him in furnishing the reports required, and that substantial progress has been made toward securing full and uniform reports, he points out that there is still a class of corporations which have a considerable part in railroad business, but of whose work it is difficult to get exact figures. These are the fast freight lines, terminal companies, car companies and other subsidiary corporations, whose operations directly concern the railroad companies, but whose accounts are separately kept, and whose income and expenses do not appear directly in the railroad reports. The task Mr. Adams has undertaken of bringing these into the statements is not an easy one, but it is hoped that his efforts will meet with full success. The use made of such subsidiary corporations forms an interesting chapter in the history of some companies—but a chapter not often published.

The Statistician has his work now well in hand, and the third report may be expected to show a still further improvement. It might be suggested that if it could be brought out in somewhat less than a year after the end of the year covered, its value to the student and the railroad man would be increased considerably.

REPORT OF PROCEEDINGS OF THE TWENTY-FOURTH ANNUAL CONVENTION OF THE MASTER CAR-BUILDERS' ASSOCIATION, HELD AT OLD POINT COMFORT, VA., JUNE 10, 11, AND 12, 1890. Chicago; published by the Association, John W. Cloud, Secretary.

The present report makes a volume of 210 pages, with 15 large plates, some 50 pages being taken up by the description of the standards, constitution of the Association, etc. The proceedings include some reports and discussions of interest, including that of the Committee on Steel Plate and Malleable Iron in Car Construction, a subject of considerable importance.

The Rules for Repair of Cars Interchanged for Traffic, with the debate upon the amendments, occupy a considerable part of the report, as they did of the time of the Convention. This is an important part of the work of the Association, and the discussion on the rules often brings out some notes of experience which are worth preserving.

BOOKS RECEIVED.

SELECTED PAPERS OF THE CIVIL ENGINEERS' CLUB OF THE UNIVERSITY OF ILLINOIS, 1889–90. Champaign, Ill.; issued by the Club. This includes a number of interesting papers prepared for and presented to the Club. Copies can be obtained from the Secretary at Champaign, Ill.; price 30 cents each.

REPORTS OF THE CONSULS OF THE UNITED STATES TO THE STATE DEPARTMENT: NO. 119, AUGUST, 1890: NO. 120, SEPTEMBER, 1890. Washington; Government Printing Office.

FRUIT CULTURE IN FOREIGN COUNTRIES: SPECIAL REPORTS TO THE DEPARTMENT OF STATE FROM CONSULS OF THE UNITED STATES. Washington; Government Printing Office.

SELECTED PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; published by the Institution, James Forrest, Secretary. The present installment of these papers includes the Effect of Chilling on the Impact Resistance of Metals, by Thomas Andrews; Calorimeters for Testing Fuels on a Small Scale, by Bryan Donkin and John Holliday; Abstract of Papers in Foreign Transactions and Periodicals.

OUR SCHOOLS; WITH PARTICULAR REFERENCE TO TRADES SCHOOLS: BY JOSEPH M. WILSON, C.E., PRESIDENT OF THE FRANKLIN INSTITUTE. Philadelphia; reprinted from the *Journal* of the Franklin Institute.

TWENTY-FIRST ANNUAL REPORT OF THE STATE BOARD OF HEALTH OF MASSACHUSETTS: HENRY P. WALCOTT, M.D., CHAIRMAN; SAMUEL W. ABBOTT, M.D., SECRETARY; FREDERIC P. STEARNS, CHIEF ENGINEER. Boston, Mass.; State Printers.

INDEX TO THE REPORTS OF THE COMMITTEE ON SCIENCE AND THE ARTS OF THE FRANKLIN INSTITUTE, 1834–90: COMPILED UNDER DIRECTION OF THE COMMITTEE BY PERCY A. BIVINS. Philadelphia; published by authority of the Institute.

FLOW OF WATER IN OPEN CHANNELS, WITH TABLES BASED ON KUTTER'S FORMULA: BY P. J. FLYNN, C.E. San Francisco; reprinted for the Author from the *Transactions* of the Technical Society of the Pacific Coast.

REPORTS ON THE PROJECTED WORKS OF THE TULARE IRRIGATION DISTRICT, TULARE COUNTY, CALIFORNIA: P. J. FLYNN, CHIEF ENGINEER. Tulare, Cal.; issued by the Board of Directors.

THE COMPOUNDING OF LOCOMOTIVES BURNING PETROLEUM REFUSE IN RUSSIA: BY THOMAS URQUHART, LOCOMOTIVE SUPERINTENDENT GRASI-TSARITSIN RAILROAD. This is a paper read by Mr. Urquhart before the Institution of Mechanical Engineers in London; it is illustrated by a number of drawings, and is supplemented by a report of the discussion on the paper.

R. UNIVERSITA ROMANA: SCUOLA D'APPLICAZIONE PER GL' INGEGNERI: PROGRAMMI D'INSEGNAMENTO E ANNUARIO PER L'ANNO SCOLASTICO 1890–91. Rome, Italy; published for the University.

REPORT OF THE MASSACHUSETTS BOARD OF RAILROAD COMMISSIONERS IN RELATION TO THE ACCIDENT ON THE OLD COLONY RAILROAD NEAR THE QUINCY STATION, AUGUST 10, 1890. Boston, Mass.; State Printers.

PERMANENT FORTIFICATION FOR ENGLISH ENGINEERS: BY MAJOR J. F. LEWIS, R.E. Chatham, England; published by the Royal Engineers' Institute.

FIFTH ANNUAL REPORT OF THE COMMISSIONER OF LABOR; 1889. RAILROAD LABOR: CARROLL D. WRIGHT, COMMISSIONER. Washington; Government Printing Office.

GENERAL SOLUTION OF THE TRANSMISSION OF FORCE IN A STEAM-ENGINE, AS INFLUENCED BY THE ACTION OF FRICTION, ACCELERATION AND GRAVITY: BY D. S. JACOBUS. Hoboken, N. J.; reprinted from *Transactions* of the American Society of Mechanical Engineers.

SOME ONTARIO MAGNETITES: BY T. D. LEDYARD. Toronto, Canada; from the *Transactions* of the American Institute of Mining Engineers.

THE WATER POWER OF THE FALLS OF NIAGARA APPLIED TO MANUFACTURING PURPOSES: THE HYDRAULIC TUNNEL OF THE NIAGARA FALLS POWER COMPANY. Niagara Falls, N. Y.; published by the Business Men's Association.

CORNELL UNIVERSITY, COLLEGE OF AGRICULTURE: BULLETIN OF THE AGRICULTURAL EXPERIMENT STATION, NO. XX., SEPTEMBER, 1890. Ithaca, N. Y.; published by the University.

THE EDGAR THOMSON STEEL WORKS AND BLAST FURNACES: CARNEGIE BROTHERS & COMPANY, LIMITED: ILLUSTRATED DESCRIPTION. Pittsburgh, Pa.; issued by the Company.

THE FRICK COMPANY, ENGINEERS: ILLUSTRATED CATALOGUE AND DESCRIPTION OF "ECLIPSE REFRIGERATING MACHINES." Waynesboro, Pa.; issued by the Frick Company.

EXHIBITION OF PICTURES BY MODERN MECHANICAL PHOTOGRAPHIC PROCESSES: NOVEMBER 3–15, 1890. New York; the New York Camera Club.

ABOUT BOOKS AND PERIODICALS.

IN BELFORD'S MAGAZINE for November Captain W. H. Parker concludes his article on the Early Discoveries of America. The other articles include an excellent variety of substantial and lighter matter.

An article which engineers will read with interest is Robert Brewster Stanton's Through the Grand Cañon of the Colorado, in SCRIBNER'S MAGAZINE for November. It describes the trip of a railroad surveying party down the Colorado from Grand Forks to the Gulf of California—the second trip ever made through the Grand Cañon. In this number also Mr. Zogbaum's account of the cruise of the Squadron of Evolution, and Professor Shaler's Nature and Man in America are concluded.

In the December number of SCRIBNER'S is the first of a series of papers on Japan by Sir Edwin Arnold. During 1891 this magazine will contain other papers on Japan by the same author; Explorations in Northern Mexico, by Dr. Karl Lumholtz; several articles on Australia, including one on the railroads of that country and the results of Government ownership; The Great Streets of the World; a series of articles on Ocean Steamships, similar in treatment to the railroad articles pub-

lished some time ago; and also the usual variety of lighter matter.

The leading and longest paper in the last quarterly BULLETIN of the American Geographical Society is on Canada, the Land of Waterways, by Watson Griffin. Other papers are on Modern Iceland, by Professor Charles Sprague Smith, and on the Upper Amazon, by Courtenay De Kalb. The Geographical Notes, by Librarian Hurlbut, contain several points of interest.

The account of the National Guard of Minnesota is completed in OUTING for November. This may be called a traveler's number, for its articles include descriptions of outdoor life and sport in Long Island, in Florida, Wisconsin, California, Canada, and Norway.

In the POPULAR SCIENCE MONTHLY for November Professor Mendenhall writes of the Relations of Men of Science to the General Public. An article by George Iles gives some suggestions on teaching geometry which are worth studying.

Switzerland and Japan are the subjects of descriptive articles in HARPER'S MAGAZINE for November, while Mr. Child continues his South American articles, his subject this month being Urban and Commercial Chili. Southern California is written of also under the title of "Our Italy," the article being descriptive and a little prophetic as well.

Charles Scribner's Sons, New York, have in preparation two books which will be of much interest to engineers. The first is the LIFE OF JOHN ERICSSON, by Colonel Church, who was an intimate friend of the great engineer for many years, and has also had the use of his papers and correspondence in preparing this work. The second is ELECTRICITY IN DAILY LIFE, an account of the applications of electricity to practical use, prepared by several writers.

The November number of the ARENA completes the second volume of that magazine, which has now fully established its place in the reading world. The life of the ARENA is discussion, and in its columns all sorts of questions, including some of the gravest importance, have been discussed with a vigor and freedom which we find nowhere else. That this method finds approval with a large public is an excellent sign, and the new magazine deserves the best congratulations on its success.

The latest quarterly number of the JOURNAL of the New England Water Works Association is the report of the Ninth Annual Convention, which was held in Portland, Me. It includes several papers of value, with reports of the discussions on them.

In the JOURNAL of the Military Service Institution for November the leading article is on Our Northern Frontier, by Lieutenant A. D. Schenk, treating of the provisions which should be made for the protection of our national interests on the Great Lakes. Other articles are on the Light Battery in Peace; on the Practical Education of the Soldier, by Lieutenant C. D. Parkhurst, and on the Development of Naval Armor, by Lieutenant John Conklin, Jr. The translations include Russian Ideas on Fortification; the German Cavalry and a Continuation of Prince von Hohenlohe's letters on Artillery, with some shorter notes of much interest.

ANSWER TO A PROBLEM IN LAND SURVEYING.

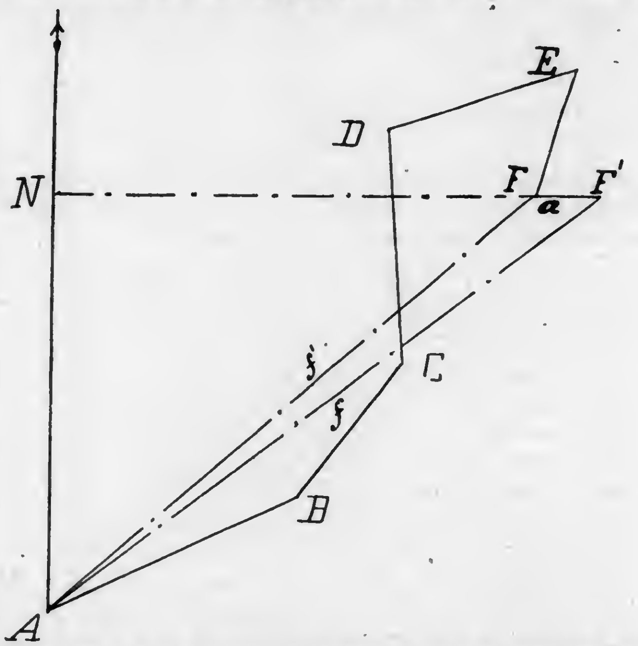
PROBLEM: *To correct a random traverse of several courses between two known points.*

This is a very common problem with which the land surveyor has to deal in the location of boundaries of irregular tracts of land, retracing old highway lines, and relocating meander lines. It seems to have escaped the attention of most authors as well as of surveyors, and it is believed that correct solutions of the problem, by surveyors in the field, are the exceptions rather than the rule.

To solve the problem we need a convenient basis of comparison between the courses and distances of the true line and those of the random. This will best be found by calculating the courses and distances of lines which will join the starting and closing points of the two surveys, calculating both as they would be according to the meridian and the measure of the random. It is better to calculate these in terms of the random, because of the greater convenience to the surveyor in applying his corrections in the field.

Preliminary Propositions.—1. A difference in length of the chains on different surveys by the same notes from a common starting-point, causes a difference in the length of the respective courses without changing their direction. Hence, the closing points of the several surveys will all lie in one straight line with the common starting-point, and the relative length of the several chains is shown by the distances of the closing points from the common starting-point.

2. The effect of using different meridians (or variation of the needle) in such a case is to swing the lines around the starting-point as a center without changing the lengths of the courses or their angles with each other. Hence if



chains are of equal length the termini of the surveys will all lie in one arc, having the common starting-point for its center.

3. Hence the position of the terminus of a random, with relation to such a line and arc, passing through the terminus of the true line determines both the difference in length of chains and of the meridians of the two surveys.

Let A, B, C, D, E, F represent a true line of several courses, and F' the terminus of a random run from A to retrace the line, the course and distance of the line $F F'$ being known.

From A draw $A F$ and $A F'$.

The angle $F A F'$ measures the difference in courses, or, in other words, the correction for variation of the needle.

The length of the lines $A F$ and $A F'$ measures the comparative length of the chains used on the two surveys. $\frac{A F}{A F'}$ is the length of the chain used on the true line in terms of the chain used on the random.

The course of any part of the broken line, as $A B$ (in terms of the random), is equal to the bearing, by the original notes $\mp$ the angle $F A F'$.

The length of any course, as $A B$ in terms of the random, is equal to the length given in the original notes $\times \frac{A F}{A F'}$.

To find the correction to be applied to the stakes in the angles of the random, first compute the total latitude and departure of each of the points in the random line.

Second, convert the notes of the true line into terms of the random by changing the bearings and lengths of the several courses, and giving them as they would be according to the meridian and chain of the random, and compute the total latitudes and departures of the several points.

A comparison of the two results will give the correction to be applied at each stake of the random.

Example.—A highway between nearest known points is described as follows :

1st. N. 62° E., 14.00 chains.
2d. N. 43½° E., 8.00 "
3d. N. 5° W., 12.00 "
4th. N. 72½° E., 10.25 "
5th. S. 12° W., 6.43 "

A random run with variation of needle 2° 17′ E. came out 62 links east of the point. Stakes were set at the angles of the random.

1. What is the variation of the needle as referred to the meridian of the original survey of the highway ?

2. How much, and in what direction, must the stakes in the angles of the random be moved, to place them in the angles of the original line ?

			N.	S.	E.	W.	Total Lat.	Total Dep.
1.	N. 62° E.,	14.00	6.57	....	12.36	....	6.57	12.36
2.	N. 43½° E.,	8.00	5.80	. .	5.51	....	12.37	17.87
3	N. 5° W.,	12.00	11.95	....	....	1.05	24.32	16.82
4.	N. 72½° E.,	10.25	3.08	....	9.78	....	27.40	26.60
5.	S. 12° W.,	6.43	....	6.29	....	1.34	21.11	25.26

Tan. $F' A N = \frac{N F'}{A N} = \frac{25.26}{21.11} = 1.19663 = \text{tan. } 50° 7' \therefore A F' F = 39° 53'$.

$A F = \sqrt{A N^2 + N F^2} = \sqrt{21.11^2 + 25.26^2} = 32.92. \quad F F' = .62.$

In the triangle $A F F'$ we now have two sides and the included angle to find the remaining parts. We will call the angles A F and F' and the sides opposite a f and f'.

$$f + a : f - a :: \text{tan. } \frac{F + A}{2} : \text{tan. } \frac{F - A}{2}.$$

$$32.92 + 62 : 32.92 - 62 :: \text{tan.} \frac{140° \, 07'}{2} : x;$$

or $33.54 : 32.60 :: 2.75621 : 2.65431$, whence $x = \text{tan. } 69° 21\frac{1}{3}'$.

$$A = 70°.03\tfrac{1}{3}' - 69°.21\tfrac{1}{3}' = 42'.$$

As the random came out east of the true line, the correction 42′ must be added to the assumed 2° 17′ to find the variation of the needle from the meridian of the original survey = 2° 59′ E. This will only need to be used in case the line is to be run over again.

To find f'.— Sin. A : Sin. F' :: 62 : f'.

$.01222 : .64123 :: 62 : 32.446.$

The length of the original chain in terms of the chain used in the random $= \frac{f}{f'} = \frac{32.446}{32.92} = .9856.$

We will now apply these corrections to the original notes, reducing them to the meridian and measure of the random, and again compute total latitudes and departures.

			N.	S.	E.	W.	Total Lat.	Total Dep.
1.	N. 61° 18′ E.,	13.80	6.63	....	12.10	....	6.63	12.10
2.	N. 42° 48′ E.,	7.88	5.78	....	5.35	....	12.41	17.45
3.	N. 5° 42′ W.,	11.83	11.77	...	...	1.17	24.18	16.28
4.	N. 71° 48′ E.,	10.10	3.15	....	9.60	....	27.33	25.88
5.	S. 11° 18′ W.,	6.34	....	6.22	....	1.24	21.11	24.64

The last course is computed simply as a check to prove the correctness of the work, which it does. We now compare results to find the corrections to be applied to the stakes in the random to place them in the true line.

	B.		C.		D.		E.		F.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
Random line.	6.57	12.36	12.37	17.87	24.32	16.82	27.40	26.60	21.11	25.56
True line.....	6.63	12.10	12.41	17.45	24.18	16.28	27.33	25.88	21.11	24.64

Stakes are to be moved as follows : At B, North, .06 ; West, .26 ; at C, North, .04 ; West, .42 ; at D, South, .14 ; West, .54 ; at E, South, .07 ; West, .72—at F, West, .62.

If it is desirable to correct the stakes by measuring a single course and distance, we may solve these small right triangles.

Taking the first one at B, $\sqrt{6^2 + 26^2} = 26.7$. $\frac{26}{6} = 4.333+$ = tan. 77° ; hence the correction is N. 77°, W. 26.7 links. At C it is N. 84° 34′, W. 45½ links. At D, S. 75° 28′, W. 55.6 links. At E, S. 84° 27′, W. 73. 3 links.

[NOTE.—This problem, submitted by Mr. F. Hodgman, C.E., of Climax, Mich., was published in the JOURNAL for September, page 417. Several answers have been received, but none were correct, and Mr. Hodgman therefore furnishes the above solution.]

AIR-BRAKE FAILURES.

IN a letter to the New York *Tribune*, Mr. P. H. Griffin, President of the New York Car-Wheel Works, makes some excellent observations on this point. After explaining the connections between the brake cylinders and the brake-shoes, which are familiar to most of our readers, he says :

When the connections are adjusted with new brake-shoes and everything in proper order, a piston travel of 4 in. will apply the brakes. As the shoes wear out or the connections give under strain or wear at the pivotal points, the piston travel must necessarily increase to effectively apply the brakes. The wear of brake-shoes is rapid, and the total effective travel of the piston is more than exhausted in the wearing out of one brake-shoe. Constant attention must therefore be given to the connections to see that they are of proper length, and inspectors at certain points have this work in charge. As a rule the work cannot be done until trains are all made up and ready for departure ; the air pressure is then applied, the travel of the piston watched, and if it is too great the connecting-rods should be shortened in order that the brakes may be applied with less piston travel and a margin of safety provided to allow for wear. The very short time available for this work, the hurry and confusion incident to the departure of trains and the pressure to gain every moment of time in this age of minutes and seconds, are serious obstacles to a proper performance of the work ; unfortunately, it cannot be done at any other time unless every car is taken to some point provided with apparatus for making a test, a practice almost impossible when the great number of cars in service is considered, as well as the one that drawing-room and sleeping cars are often in service constantly for months at a time. Even when the test is made, it is almost invariably the case that not over 40 to 50 lbs. pressure is used, with the result that sufficient strain is not brought upon the connecting-rods to apply the brakes with any pressure adequate for service, and the connections are pronounced all right by inspectors, when if a pressure of 70 lbs. were used, they would be found unfit for service.

The reports of the Michigan Central Railroad show that 2,316 cars passed Windsor, Ont., in the year 1889 with the pistons of air-brake cylinders travelling 12 in.; on such cars absolutely no braking power was obtainable.

Nearly all of these were sleeping cars running through from distant points, the inspection and care of brake attachments being given by different railroad companies. In transferring the cars across the river from Detroit to Windsor, and *vice versa*, time was afforded for testing the piston travel and a record taken with the above result. I do not know of any other railroad company making a systematic record of the kind. During the last year the Michigan Central have equipped their cars with indicators, operating automatically, that show the exact condition of piston travel at all times. When the indicator is used the maximum travel of the piston is always shown, and the necessary alteration to take up wear can be made at any time. From a careful investigation of the subject on many of the leading railroads of the United States and Canada, I have no hesitation in saying that on one quarter of all

cars in service the braking power is so small as to be absolutely useless in case it is necessary to make a sudden stop, for the causes given above. In every-day practice it can readily be seen that in making the usual stops an engineer can handle his train without difficulty; he knows perfectly the control he has over it, whether a moderate pressure will suffice, or whether extra pressure must be used. The latter is always dangerous, through liability to stop and slide wheels with entire loss of control. But when danger confronts him and he must strain everything for an immediate and unexpected stop—well, we know they are not always made, and that the difference of a few hundred feet has a terrible result. Investigation follows; it is said that "the air-brakes failed to work," and that is the end of it. I firmly believe if the attachments through which the air-brake does its work were always in proper condition accidents from this cause would be very rare.

The conditions of service above explained are in no way attributable to any feature of air-brake construction or application. The manufacturers of air-brakes have been indefatigable in their efforts to improve and perfect their devices. Without their labors it would be absolutely impossible to run trains at the speeds in practice to-day. It is only just to them, therefore, that accidents so commonly attributed to the failure of the air-brakes should be located where they belong, and that every effort be made on the part of railroad managers to supplement the valuable appliances now obtainable with every safeguard that can be found for their effective use.

FRICTION AND LUBRICATION OF JOURNALS.

(From the *Practical Engineer.*)

THERE is before us an interesting and valuable paper by Professor John Goodman, read before the Manchester Association of Engineers, giving the results of his own laborious investigations, as well as summarizing the work of others, and suggesting forms of bearings for journals more in accordance with the production of a minimum amount of friction than present practice.

Among many interesting facts, Mr. Goodman points out that the friction per square inch of a journal thoroughly lubricated, and so running upon an oil film, is, within limits, independent of the load. The limit is imposed by the pressure which the oil film will bear without being squeezed out and allowing the metals to come into actual contact with each other. At low speeds, however, the friction is greater than at high speeds, and it has been found to decrease gradually till a surface speed of 1,000 ft. per minute is attained, when it varies very slightly, being in fact practically constant for a considerable range. This is true, however, only for considerable loads per square inch, such as 400 lbs., the area of the journal being estimated by multiplying diameter of shaft by length of bearing.

At loads under 60 lbs. per square inch, according to Goodman, the friction gradually *decreases* with a reduction of speed, but when the intensity of the load is greater than this the friction increases when the speed falls below 50 ft. per minute. With low speeds a load greater than 60 lbs. per square inch seems to squeeze out the lubricant, and so increase the friction. The experiments elicited one interesting fact well known in practice to railroad engineers, namely, the effect of slight side-play in reducing the friction of a journal. A journal with a slight side-play, and moving from side to side, has greatly less friction than one in which the side-play is entirely taken up. It is, of course, impossible to allow any great amount of side-play to the crank-shaft of a steam engine, but still this fact proves how advisable it is to fit main brasses and connecting-rod brasses slightly easy, and explains the heating which is often caused by too good a job being made of the side fit.

A constant load must be less in intensity than an intermittent one; thus a dead load, such as is usually allowed on railroad axles, should not exceed 450 lbs. to 500 lbs. per square inch, while in crank-pins, where the load is intermittent, a maximum of 2,000 lbs. per square inch is often applied without heating. On the gudgeon ends, where the sliding velocity of the surfaces is not high, as much as 5,000 lbs. per square inch is allowed. The load, however heavy, takes some time to squeeze out the oil film, and so a heavy load only momentarily applied and then reversed does not get time to bring the metals into actual contact, although a smaller load continuously applied is quite able to do so. The whole efficiency of the journal depends upon its support upon this lubricating film, and the friction is caused, not by the contact of the metal surfaces, but by the continuous work of shearing the oil film existing between those surfaces. According to Goodman's experiments, this oil film measures from 0.0001 to 0.0004 in. thick. It is very interesting to reflect that the efficient working of our great engines depends on a lubricating film of from one ten-thousandth to four ten-thousandths of an inch thick, and furnishes one more illustration of the minute matters to be examined into before we can be said to understand the simplest actions of those great machines.

It is very customary in engines to oil the bearings from a hole in the upper brass by a syphon lubricator passing oil into grooves, but this, it appears, is bad practice, as the rotation of a journal causes a species of pumping action, which tends to force oil out at that very point. In some experiments it appears that when oil was supplied to the bearing from below, a continual stream of oil was forced up through the oil hole from the grooves, and on stopping up the hole the friction of the bearing at once diminished as much as 25 per cent. When the hole was opened it at once rose again. We may mention that in this case the load on the bearing came upon the upper brass in the same manner as if the upper brass were pressed down by a weight. The closing of the hole caused an oil cushion to be formed under the brass, and so diminished friction. Professor Goodman therefore recommends that oil grooves should not be placed along the line upon which pressure comes. When the pressure comes upon the lower brass, an oil groove in the upper brass is in the proper position, but when the pressure comes on the upper brass this is a bad arrangement.

When the pressure is vertical, as in a horizontal mill-shaft, the friction is greatly reduced by cutting away the sides of the brass, and the brass in contact gives the best results for minimum wear and friction when the brass width is seven-tenths of the diameter of the journal.

The Author recommends that brasses should never subtend an angle greater than 90°, the sides being cut away and pads inserted. Pad lubrication is confidently recommended as giving the minimum of friction and oil consumption as well. It consists in applying a woolen or felt pad kept soaked with oil and lightly pressed against the bearing, the supply of oil being kept up by means of lamp cotton, which soaks it up from a reservoir below.

As illustrating the efficiency of this method of working, we give the following case: A new pad weighing 14 drachms was supplied with 2¼ oz. of rape oil, and placed in contact with a 7-in. journal; total load on the brass, 4,984 lbs., or 237 lbs. per square inch. At the end of 319,660 revolutions, which is equivalent to 1,239 train-miles, the oily pad was weighed and found to be 2 oz. 2 dr.; hence only 1 oz. of oil had been used. The revolutions per minute were 166; the mean temperature of the journal was 130° Fahr., which rose to 145° at the end of the experiment; the mean coefficient of friction was 0.010, which rose to 0.012 at the end of the experiment. This is stated as the best result the author has obtained, but in many similar experiments the equivalent distance was over 1,000 miles.

In conclusion, the results of Professor Goodman's experiments seem to point to clearing away brasses, except at surfaces in line of pressure, limiting angular arc to 90° and introducing oil at the gaps by pads. A gas engine, whose bearings had been altered in the manner indicated, recently gave a mechanical efficiency of 90 per cent., which is very remarkable for a gas engine which has only one impulse for two revolutions.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

XIII.—THE DRYING OF PAINT.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page* 455.)

With the possible exception of durability, no quality of paint is more important to the consumer than its drying properties. Where there is an enormous amount of painting to be done, so that the painters can be kept constantly at work, and where there is an unlimited amount of room for the storing of the articles to be painted, it is, of course, no serious matter if the paint is two, three, or even four days in drying; but these circumstances, so far as our observation goes, almost never occur together. On railroads there is usually an enormous amount of painting to be done, but the track room, on which to store cars while they are drying, is usually quite limited in extent, and still another element of great weight comes in—namely, the loss of the use of the equipment while the paint is drying, provided it dries slowly. A single illustration will perhaps make this point clear. It is not at all rare that a railroad company has facilities sufficient for the manufacture of anywhere from 10 to 25 or 30 freight cars per day at one shop. Taking 20 as an average case, it is readily seen that if four days are required for each coat of paint to dry, track room enough must be provided to store 160 cars, since it is customary to give each freight car two coats of paint, and if the second coat cannot be put on until the fifth day, 80 cars would be first coated before a beginning could be made in second coating, and none of these on the supposition could be turned out until four days longer. We query whether there is a great manufacturing establishment or a railroad company in the United States which could without serious inconvenience furnish track room for 160 cars while they are being painted. Still further, as will be noted, after the car is finished in every respect except painting, on the supposition made above, it is six or eight days before it can go into service. This loss of service is no small matter, and as orders are usually not placed with the shops for cars until they are needed, and generally badly needed, the necessity that the paint should dry rapidly is certainly a matter of no small moment. We have, of course, taken an extreme view of the subject, as it is very rare, or perhaps almost never, that paint is used of such a kind that it takes four days for drying. The present practice, so far as our knowledge goes, usually turns a car into service the third morning after the painting is started, but even this causes such difficulties in the large shops that constant efforts are being directed toward the securing of paint which will dry more rapidly. Indeed, if our experience is of any value, almost every point, even durability, is in many cases sacrificed to rapid drying. Still further, so great is the necessity for securing rapid drying, that some large corporations are spending a great deal of money in providing facilities and special appliances in the way of shops for securing proper conditions, simply as a means of hastening drying. In the new passenger-car paint-shop of the Pennsylvania Railroad Company, at Altoona, devices have been made use of and appliances furnished, which cost no small amount of money, with no other idea in mind than to secure more rapid drying. It is perhaps not too much to say that any modification or device by which the total time of painting freight cars would be shortened six hours, and the time of painting passenger cars shortened three or four days, would be heartily welcomed by railroad companies. Of course everything cannot be sacrificed to this point, but a good many concessions can be made.

The drying of paint, so far as our observations go, depends a good deal on what the material is that is used to hold the pigment to the surface. In some cases the drying of paint is almost entirely evaporation; in other cases it is a complicated chemical process, and in other cases it is both. We will see if we can do something toward making these points clear. First, where the material that is used to hold the pigment to the surface is largely or almost entirely linseed-oil, drying is in a very slight sense evaporation. The drying in this case is a chemical change in the oil, resulting in the formation of an entirely different chemical body. Linseed-oil before drying is, as is well known, an oily, greasy liquid. Dry linseed-oil has entirely lost its oily condition and pretty nearly lost its greasiness, and is in reality a leathery, elastic substance, having more or less transparency and considerable tenacity, a melting point somewhere above 200° F., very insoluble in most substances, and when properly protected with pigment in ordinary paint a very durable substance. Unfortunately it is not water repellent, at least during the first month or six weeks after it is applied. The name given by Mülder to the principal constituent of dried linseed-oil is "Linoxyn."

Pure linseed-oil when exposed to the air changes from the oily condition to the dry condition very slowly. In the experiments which we have made we have hardly ever succeeded in getting pure linseed-oil alone to dry in less than four days, even under favorable conditions. It does dry, however, and like a number of other oils generally known as "drying oils," it seems to have within itself the characteristic of starting the process which results in the dry material. Quite a little study has been put on the question of what changes take place in linseed-oil during drying. As said above, unquestionably the drying of linseed-oil is a chemical operation, and is not, as many seem to think, a case of evaporation. We have not been able ourselves to make many positive experiments on the chemistry of the process. Mülder has given more study to the subject than any other experimenter with whom we are conversant, and if we understand him rightly his experiments seem to indicate that during drying linseed-oil takes up oxygen from the atmosphere or other sources, and gives off carbonic acid, acetic acid and formic acid. These three products, if we read Mülder correctly, he demonstrated to be formed and given off from the oil during drying. There is also the strongest probability for believing that water vapor is one of the products of the drying of linseed-oil. The circumstances under which Mülder conducted his experiments, however, did not enable him absolutely to demonstrate this point, but the reactions which he figures out require that water vapor should be formed in the process. A number of interesting experiments confirmatory in one way or another of these views have been tried. For instance, it is demonstrated that if linseed-oil is deprived of oxygen, it does not dry for weeks. Thus, if the inside of a flask is coated with linseed-oil and then the flask closed, drying does not take place for months. If, on the other hand, the air is changed in the flask, drying takes place readily. Furthermore, it is well known that at low temperatures drying takes place very slowly, as is also the case in a damp atmosphere. All these things are readily explained, if we understand the matter rightly, on the supposition that oxygen is taken up by the oil during drying, and that certain volatile products are given off. If oxygen is not fur-

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the Journal for December, is on the Work of the Chemist on a Railroad; No. II, in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils; No. VIII, in the July number, on the Method of Purchasing Oils; No. IX, also in the July number, on Hot Box and Lubricating Greases; No. X, in the August number, on Battery Materials; No. XI, in the September number, on Paints; No. XII, in the October number, on the Working Qualities of Paint. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these Contributions to Practical Railroad Information of special value in indicating the true character of the materials they must use and buy.

nished, of course the chemical changes cannot take place. If the oil is in a closed place, although oxygen may be present, the space may become so saturated with carbonic acid, water vapor, and other volatile products formed during drying, that no more can be taken up by the air, and consequently drying stops. Furthermore, it is a general rule that low temperatures do not facilitate chemical reactions, while high temperatures do facilitate them, and finally if the air is saturated or nearly saturated with moisture, the escape of the moisture from the oil during drying into the air is retarded, which accounts for the fact that in damp weather oil dries more slowly. It is interesting to note that Mülder's experiments seem to indicate that, although we are accustomed to say linseed-oil is dry in the course of from two to four days, yet actually the chemical action goes on more or less for several months. Indeed, at one place Mülder cities that, as the result of direct experiment, chemical action had not ceased at the end of four months. Also Mülder is inclined to the view, if we understand him rightly, that the direct action of the sunlight is a very important matter in the drying of linseed-oil. Our own experiments rather incline us to the view that, so far as external circumstances are concerned, about the best which can be done to facilitate the drying of paint is to furnish warm dry air to the surfaces. A change of air is very essential, and this alone facilitates drying very greatly. If in addition the air is dry and the temperature from 90° to 100°, or possibly 110° F., drying takes place very much more rapidly.

The fact noted above by Mülder, that chemical change goes on for a period of time, is to our minds a very interesting one, and possibly explains what has already been noticed in previous articles—namely, that freshly dried linseed-oil is for at least a month or two more or less water absorbent, while very old dried linseed-oil seems to have lost this property to a greater or less extent. It is quite probable that a condition is ultimately obtained by the dried linseed-oil, in which its water-absorbent power becomes very small, with consequent increase in durability. The practical point which we draw from this information is that the probabilities are it is extremely desirable to have the drying progress as far as possible before the work is turned out or exposed to the elements, and our belief is that if the drying takes place in warm, dry air for from 36 to 48 hours before the work is turned out, the paint will have very much greater durability.

If Mülder's experiments are correct, and we see no reason to doubt them, it is obvious that linseed-oil can hardly be said to be fully dry until all the chemical change has taken place, and this, depending on the surroundings, may take months. It is obvious, therefore, that the question of when oil or paint is dry is subject to a great deal of uncertainty, and it is essential, therefore, to define what is meant by "dry." Practical painters have a number of terms in use which express to their minds the condition of the work, as, for example, "dust dry," "surface dry," "tachy," "ready for second coating," etc. These terms are, of course, variable, and being largely a function of the painter, it is hardly possible to compare different lots of paints. The practice in no two shops, so far as we are conversant, is entirely similar, and what one calls "dry," another calls "dry enough for second coating," or is "slightly tachy," or uses some other expression to characterize. In view of this difficulty of having some method of measuring the relative dryness of different paints, early in our study of paints, we set ourselves at work to devise a test for drying, not so much a test for the dryness of paint as a test for the dryness of linseed-oil which contained no pigment. We followed several lines of experiment, and finally decided on the following as enabling us to measure the relative dryness of different samples of linseed-oil. Take the material under test, lay it flat, and put on one edge of the surface three or four fresh No. 2 shot; then raise the edge where the shot are until the surface is vertical. If the material is dry the shot run off freely without interfering with the surface; if the material is fresh or not dry, they will stick or run down slowly, carrying some of the material with them. In our practical experience we have found this test to be a fairly good one, and it certainly enables comparisons to be made between the relative drying power of various mixtures of oil and japan which are entirely satisfactory. We are well aware that it is characteristic of certain mixtures to dry on the surface and not dry underneath, and that the method given above would not detect a failure to dry underneath. We do not offer the method as one covering every phase of the problem, but only as a means of comparing the relative dryness. We have never used the test much on paints, but see no reason why it should not apply equally well to paints. Of course it is obvious that the test can be varied by varying the size of the shot. The finer the shot the dryer the plate would have to be in order to prevent sticking and failure to run down the side. It is quite possible that the test may be expanded by sufficient experimenting to cover various phases of painting; for example, certain size shot might be used to tell when a paint was ready for second coating, and a different size to tell when it was ready for striping or putting on gold leaf, etc. It is, of course, obvious that where the paint must be tested on the work the method described above is not applicable, since the surfaces cannot have their positions changed. It will suggest itself readily to any one that by supporting the shot against a vertical surface for a second or two without using pressure would probably answer the purpose, the same as applying the shot when the surface is horizontal. We are quite willing to allow that a perfectly satisfactory test for drying, which can be used everywhere and which will give the same results every time, is still a desideratum, and the above test is only offered as a partial solution of the problem.

The slowness of the drying of linseed-oil, above referred to, has led to a large amount of experimenting for methods which would hasten the process. As already explained, four days is altogether too long to allow for a single coat to dry, and accordingly "dryers," as they are called, are in almost all cases added to paint to facilitate drying. We are free to confess that the action of dryers is not clearly understood, by ourselves at least. The facts seem to be these: Certain salts when put into linseed-oil have the property of very greatly facilitating the chemical change which we call drying. These salts may be certain oxides combined with the fat acids of the oil, forming in reality what we call "soaps," or they may be definite salts added to the oil in solid form. The most common illustration of the former is the substance known as "japan." Japan in reality, as we understand it, is simply lead and manganese soaps dissolved in turpentine These soaps may be made by taking raw linseed-oil and heating it, with proper amounts of lead and manganese oxides, until chemical combination takes place between the fat acids of the oil and the oxides. Gum shellac, which is largely a free acid if our experiments are correct, may be added also and heated with the oxides, in which case a soap is made consisting of a combination between the oxides and the shellac. Some manufacturers also add certain of the copal gums to their japans, and the whole is finally dissolved in turpentine. As an example of solid dryers we may mention borate of manganese and acetate of lead. It will be understood that the dryers mentioned do not profess to cover the ground of materials which may be used to start and facilitate the drying of linseed-oil, but only to give examples. We hope, later on, to devote a whole article to the question of japan, and will therefore content ourselves here with saying that in some way, which we do not fully understand, the presence of a small amount of japan, made as above described, or of some of the solid dryers, shortens the time of drying linseed-oil from four days down to, under favorable outside conditions, as short a time as eight to 12 hours. Perhaps the best practice in railroad painting may be stated to be that a fresh coat is added every day. This practically allows 24 hours for the previous coat to dry and harden.

It is an interesting question as to why the presence of small amounts of the soaps above described, or the solid dryers, should facilitate the chemical change which causes linseed-oil to dry. We are not aware of any investigation which has demonstrated exactly how the dryers act, or why they facilitate the drying. We do know that so small a percentage as about 2.00 per cent. of properly prepared lead and manganese soaps, added to linseed-oil, will cause a

sample of linseed-oil, spread in a thin layer on a glass plate, to be practically dry in from two to four hours, while the self-same linseed-oil spread in the same thickness of layer on a glass plate, and without the addition, will be from three to four days in becoming equally dry. We presume many practical painters will regard this statement as subject to some doubt, but we should be very glad to demonstrate the truth of it to any one who feels in doubt. As we will try to make clear when we come to the article on japan, the method of making the lead and manganese soaps, and the consequent resultant qualities which they have, are exceedingly important elements in the drying. Not every japan is a good one, and the difference in the drying power of various commercial japans of the market is very wide.

If now our analysis of what constitutes the drying of linseed-oil is correct, it would seem very clear that in order to secure rapid drying of pure linseed-oil, the following conditions are necessary: First, the presence of a proper amount of properly prepared dryer added either in the form of japan or in the form of some of the well-known solid dryers; and, second, the furnishing of such outside conditions as will facilitate the absorption of oxygen and the escape of the volatile products formed during the drying of the linseed-oil. Laying aside the action of light, as being not under control, except that the shop should be made as light as possible, this last requires at our hands three things: First, change of air both to facilitate the supply of oxygen and to carry off the volatile products formed during drying; second, dryness of the air, since both the chemistry involved in drying, as above explained, and also all our experience indicates that the power of the air to take up moisture facilitates the drying of oil; third, raising the temperature as high as the work will bear, since almost all chemical changes are facilitated by the action of heat. If outside air is made use of to surround the work during drying, and fresh air is constantly taken in, no special facilities will be required to dry the air before it goes to the work, since the raising of the temperature of fresh air increases its capacity for taking up moisture, sufficient to make the air comparatively dry as it comes to the work. If, on the other hand, the air in the shop, as is now the case in some of the best shops, is used over and over again by a system of fans and pipes, being warmed as it goes into the shop, it may be essential to use some artificial means of taking the moisture and other products formed during drying out of the air as it returns from the work. We are not aware that this has been carried out practically on a large scale, since the passageways through which the air comes back to the heater usually themselves serve as condensers, and retain the largest portion of the products given off by the work during drying. It is undoubted, we think, that special appliances made use of to remove from the air, which has once been in contact with the work, the products which it has taken up from the paint, would greatly facilitate the drying in such shops as are fitted with the circulating systems.

The various requirements mentioned above as essential to get rapid drying may perhaps all be summed up in the single sentence—namely, use a good dryer and furnish the work during drying with a constant change of warm or heated air.

Thus far we have considered drying as a chemical change, and have not regarded that the material holding the pigment to the surface has anything in it which is volatile, except the products which are formed as the result of the chemical change described. So pure a case of drying as this is very rare, however, as we will try to make clear a little later. But before doing this we will consider what may be called "drying by evaporation." It sometimes happens in painting, and especially in what is known as carriage painting, that the material which holds the pigment to the surface is very little of it oil. Japan is largely used as this material, and there may be cases in which japan alone is used as the material to hold the pigment to the surface. In this case the drying is very largely, we hardly like to say wholly, a simple question of evaporation. As already described, most of the japans of the market are simply lead and manganese soaps, made by combining the acids of linseed-oil with the oxides of these substances, or by combining shellac with the same oxides, and many times containing more or less copal gum, the whole being held in solution by spirits of turpentine. These would be regarded as legitimate japans. There are also large quantities of japans containing practically the same soaps, in which benzine enters as an important part of the solvent. Sometimes the lead and manganese soaps are dissolved in benzine; again a mixture of benzine and turpentine is used. Rosin is also a frequent constituent of many cheap japans. Whatever be the solvents, the lead and manganese soaps, with the gums and oil uncombined, if any are present after the solvent has evaporated, are the materials which hold the pigment to the surface. These soaps without solvent are, so far as our experience goes, plastic, pliable, tenacious, leathery substances, with very little or no disposition to stain, and more or less adherent to any surface which they may happen to have been applied to. We should hardly like to say that lead and manganese soaps, from which the solvent has been evaporated, undergo no chemical change before they are fully dry, but practically these lead and manganese soaps are dry to the touch as soon as the solvent is gone. If now a paint is made, using japan wholly as the liquid, it is very easy to see how drying becomes simply an evaporation of the solvent. In our experience and observation it is hardly good practice to use japan alone, and we presume few master painters would recommend to do fine carriage painting with nothing but japan to hold the pigment to the surface, the reason being that the general belief is that the more japan in a paint the less its durability. In painters' language, "japans burn up the paint." As we will explain somewhat later, our own ideas on the subject are that it is much more important who makes the japan and how it is made than that oil should be a constituent of the material which holds the pigment to the surface, as we have some quite remarkable experiments showing extraordinary durability, where japan was a very large constituent of the paint, the only precaution being that the japan was, as we say, properly made. We have, however, cited the case of using japan only to hold the pigment on the surface simply to illustrate what is meant by drying by evaporation, in the same manner that in the early part of this article we have described somewhat at length the drying of linseed-oil as an illustration of drying due to chemical change.

In actual practice at the present time, so far as our observation and experience goes, the drying of paint combines both of these elements. This will be clear when it is stated that most of the paint used, both for what is technically known as house painting and also for what is known as carriage painting, contains, in addition to the pigment, linseed-oil and japan, varying in amounts, of course, from a very small amount of japan, if it is a good one, in house painting, to a relatively very large amount of japan in some cases of carriage painting; and since, as has already been described, japan contains either turpentine or benzine or both, as volatile constituents, it is easy to see that when the paint is spread on the surface both volatilization of the turpentine and benzine and chemical change of the oil must result before drying is complete.

This is perhaps the place to make clear what we regard as an exceedingly important distinction in the use of dryers in painting. Confining ourselves more especially to japans, since our experience with solid dryers is very small, we find that all japans when added to linseed-oil in the same amounts do not produce drying in the same time, but that each japan has its own characteristic best amount to give the most rapid drying. For example, some japans produce the most rapid drying when the proportions are 95 parts of oil to 5 parts of japan; others give their best results when the proportions are 90 parts of oil to 10 parts of japan by weight. Still others give their best results when 70 parts of oil are treated with 30 parts of japan, and so on. The cause of this variability in the drying power of japans we are hardly able to make clear without occupying much more space than can be devoted to that subject in this article, and so we content ourselves with citing the fact, about which there is not the slightest doubt, as a great many experiments clearly prove.

It follows from this that if less than the best amount of any particular japan is used, the drying will be slower than it would be if the right amount is used. The following fact also follows, and this, to our minds, is very singular—namely, that if more than the right amount of certain japans is used the drying is actually retarded. We are quite well aware that it is customary among painters, if they want to get more rapid drying, to add more japan, and under certain circumstances, which we will explain a little later, this is admissible; but our experience, backed by a very large number of experiments, and also by the testimony of a good many practical painters, is that certain japans will not bear such treatment; in other words, strange to say, a proper amount of certain japans facilitates drying; an increase in amount retards drying. We have studied a good deal trying to explain this peculiarity and to discover not only what japans were characterized by it, but also to find out whether this peculiarity was controllable. In other words, can a japan be made which will behave as above described—namely, when used in the right amount give good results in drying, but when used in larger amount retard the drying, and also can a japan be made which can be used in any amount and give more rapid drying the larger the amount used? We are able to say as the result of our study that both of these ends can be accomplished—that is, we can make a japan which used in a certain amount gives the very best possible results in drying, but which in larger amount causes a retardation in drying, this retardation being a very serious matter. We have actually under test used with exactly the self-same oil and the same method of testing a certain amount of a certain japan, and obtained drying, as above described, in from two to four hours. A larger amount of this self-same japan, every other condition being the same, would not dry in a much longer time. Also we are able to say that a japan can be made which can be used in any amount, and the drying is more rapid the larger the amount of japan used. Our studies still further indicate that the first of these two kinds of japans is the best for facilitating that chemical change in the oil which we call drying; also that the second of these two kinds of japans can be used where the first is not so applicable—viz., under unfavorable conditions, and that it dries mostly by evaporation. Our studies also indicate that most of the commercial japans aim to embody in one japan the good qualities of both—namely, it is hoped, so far as the subject is understood by those making most of the commercial japans, that they give the greatest possible assistance in producing the chemical change called drying, and at the same time can be used under unfavorable conditions by increasing the amount, and thus enable drying to be produced largely at least by evaporation. Our own experience indicates that these two qualities are so diverse, and to a certain extent so antagonistic, that in our final conclusions, in regard to what is the best japan, we have decided to make two japans instead of one, and to make each of them characteristic of one of the two desirable qualities above mentioned. The first we call our standard japan, and this is the most powerful dryer we have ever seen, provided by drying we mean the chemical change in linseed-oil edscribed above. The second we call emergency japan, and this, while it does to a certain extent assist the chemical change in the oil called drying, can nevertheless be used in almost any amount, and consequently produces the principal portion of the drying by simple evaporation of the solvent. We have not succeeded in getting satisfactory results with any japan which tries to combine into one these two different modes of action.

We will not attempt in this article to describe how these two kinds of japan are made, since this article is not especially on the subject of japan. It is perhaps sufficient to say that, according to our experience, if it is desired to obtain the most rapid possible drying, and still have the material holding the pigment on the surface almost all linseed-oil, which we may say is the customary recommendation of most practical painters, a certain amount of japan and only a certain amount of it must be used, which japan has the characteristic of facilitating the oxidation of linseed-oil to the maximum. If, on the other hand, there is no question about the material which holds the pigment on the surface, and no special desire to have as much of it linseed-oil as possible, another kind of japan can be used which will given even more rapid drying—that is, a japan which dries very largely by evaporation, since evaporation of solvent in a corresponding thin layer is much more rapid than chemical change. Later on we will give the results of some experiments, showing relative durability of paints, in which the vehicle is nearly all linseed-oil and in which the vehicle is nearly all japan, and will only add here that if the vehicle is almost all linseed-oil, the best that we have ever been able to do is to produce a drying which will bear a second coat in about eight hours under moderately favorable conditions; this with the use of our so-called standard japan. Also that with the use of our emergency japan we have many times been able to second coat in four hours, without difficulty.

In regard to boiled oil, which is a legitimate part of the drying of paint, we will say that, so far as our knowledge goes, two changes are produced in the oil by boiling: First, there is formed in the oil in small amount, varying from 1.00 to 4.00 per cent, lead and manganese soaps, caused by the addition of the oxides of these substances to the oil, and its combination with them during the boiling. Second, there is also probably, and we use the word probably to cover our lack of knowledge on the subject, a certain chemical change introduced in the oil by the action of the heat and the exposure of the oil to the air at a high temperature. Laying aside the chemical changes introduced, it is obvious that the reason why boiled oil dries more rapidly than raw oil is due to the presence of the lead and manganese soaps, as already previously described. Of course we do not wish to be understood as saying that the presence of these soaps is the only element, but simply to indicate that, so far as our knowledge goes, rapid drying is in almost all cases the resultant of having in the oil some solid or liquid dryer. To so great an extent is apparently the drying of boiled linseed-oil a function of the presence of the lead and manganese soaps, that it is customary to make boiled oil at present without ever putting it in a kettle. A small amount of either regular japan or oil dryer is added through the bung-hole of the barrel giving rise to what is known as "bung-hole boiled oil," and the lead and manganese soaps thus added form a pretty fair boiled oil.

In general we do not favor the use of boiled oil, since we have never been able to secure as rapid drying with boiled oil by any modifications which we could make of it, as we have secured with raw oil and the proper amount of japan. We know there is a strong prejudice among many painters in favor of boiled oil on account of a believed greater durability. We cannot yet give the results of positive experiment on relative durability, but to our minds the difficulties in the way of obtaining satisfactory results in drying from boiled oil are so great that we do not under any circumstances recommend its use.

We will only add that, in our judgment, very little of the so-called boiled oil of the market is made by the old method—namely, by adding litharge and oxide of manganese to the oil in the kettle, and cooking it for a period of time. Of course some manufacturers do this and make a specialty of it, but by far the largest portion of the boiled oil which we have examined is made either by the addition of solid dryers or of japan to the oil in the barrel, or possibly by the addition of japan or oil dryer to the oil in the kettle, and heating moderately for a period of time. In our judgment the bung-hole method is not to be approved, since it is unquestionably a fraud. The party using the oil could equally well obtain the same results by adding the japan to the raw oil. The method of adding japan or oil dryer to the oil in the kettle and then heating it moderately we see no reason to disprove, and indeed we have made a sample of boiled oil in this way which was pronounced by practical men as better than any boiled oil they had ever seen. In the next article we will take up the question of covering power.

The subject of paints and painting is so important, involves so large an expenditure of money by railroad companies, and covers so wide a field, that much space is necessarily required to cover it properly.

(TO BE CONTINUED.)

UNITED STATES NAVAL PROGRESS.

So far the new vessels completed and added to the Navy have been all of the unarmored cruiser type, but with the new ships recently put under contract the heavier fighting vessel or battle-ship type will begin to be an element in the new fleet. The first of these will be the reconstructed *Puritan* and the *Monterey*, both coast defense ships, which are making steady progress. These will be followed by the *Maine* and the *Texas*, and later by the three battle-ships just put under contract.

THE HARBOR DEFENSE RAM.

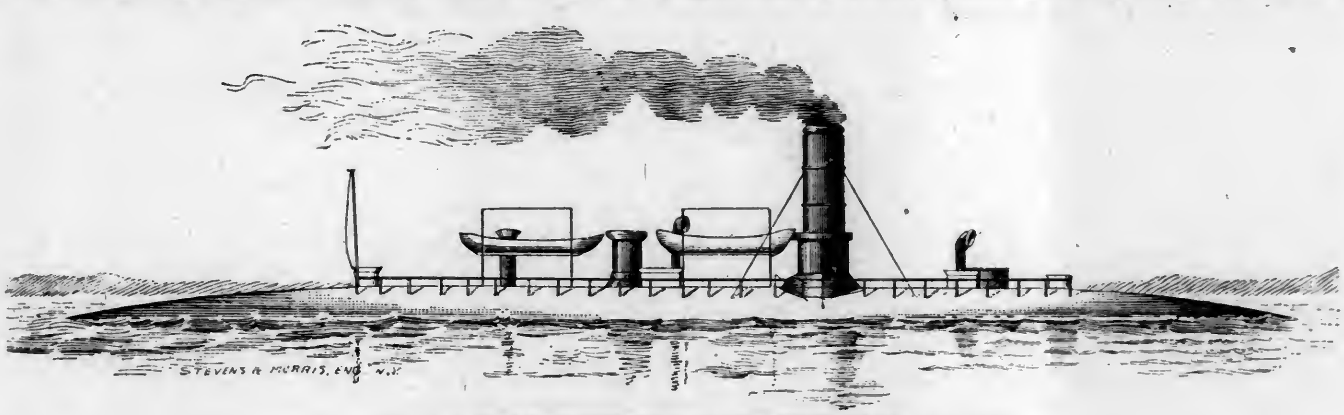
The accompanying illustration shows the general design of the twin-screw armor-plate harbor defense ram—commonly called the Ammen Ram from the fact that it was designed by Rear-Admiral Ammen—for the construction of which bids have been asked by the Navy Department.

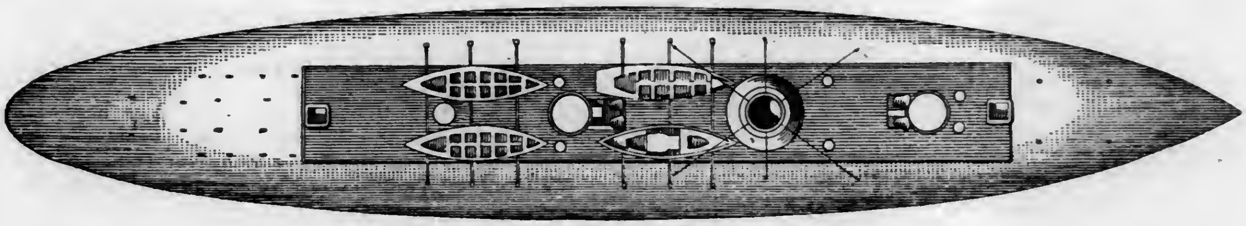
The principal dimensions of this vessel are: Length over all, 243 ft.; length on load water-line, 242 ft.; extreme breadth, 43 ft.; breadth at water-line, 41 ft. 10 in.; draft amidships, 15 ft.; displacement, 2,050 tons; indicated H.P., 4,800; speed, 17 knots per hour.

The outside strake of the deck armor is to be 6 in. thick; the next strake inboard to taper in thickness in its breadth from $5\frac{1}{2}$ to $2\frac{1}{2}$ in., the remainder of the deck plating to be $2\frac{1}{2}$ in. thick, including the lower course. The side armor is to be 2 strakes in depth, the upper 6 in. thick and the lower 3 in., to be secured by bolts with countersunk heads driven from the outside through wooden backing of yellow pine and two backing plates, each 15 lbs. per square foot, and set up with knots and rubber washers. All hatches through the armored deck are to be furnished with battle-plates, and the smoke-pipe and ventilators are to have inclined armor 6 in. thick. The conning-tower is to be 18 in. thick.

The only projections above the deck are the conning-tower, the smoke-pipe, the ventilators, the hatch-coamings, and the skid-beams upon which the boats are supported.

The officers' quarters will be on the after berth deck, and the quarters for the crew will be partly aft and partly forward. There will be a complete installation of electric lights arranged in duplicate. The drainage system will be so arranged that any compartment can be pumped out by the steam pumps. Foul air will be extracted from all parts of the vessel by means of blowers, fresh air being supplied from the main ventilator, through air ducts led along the inside of the deck.





HARBOR DEFENSE RAM FOR THE UNITED STATES NAVY.

The vessel is designed upon the longitudinal and bracket system, with an inner bottom extending from the collision bulkhead to the stern. The longitudinals and girders supporting the deck are to be continuous, converging to the stem casting and to the stern; the frames and beams to be intercostal. The depth of the longitudinals and the vertical keel throughout their length is to be 24 in.; the girders supporting the armored deck are to be 15 in. The vertical keel, two longitudinals, and the armored shelf on each side of the vertical keel are to be water-tight, forming transversely six compartments, which are divided longitudinally by water-tight frames. By this means the space between the inner and outer skin is subdivided into 72 compartments. The transverse and longitudinal bulkheads between the inner skin and deck armor divide this space into 30 compartments, making a total of 102 compartments in the vessel.

The ship is to be provided with a removable wrought-steel ram-head to be accurately fitted and securely held in position in the cast-steel stem.

The framing of this ship will be very heavy and strongly braced. As shown by the illustration, the greater part of the vessel will be submerged, while nearly all of the surfaces appearing above water are curved, leaving no opportunity for a square blow from a shot. The shop will carry no armament, depending entirely upon ramming for her offensive strength.

The vessel will be submerged to fighting trim by means of fourteen 8-in. Kingston valves, one in each transverse water-tight compartment of the double bottom. Sluice valves will be fitted in the vertical keel, and the water-tight longitudinals in these compartments.

The engines are triple-expansion and of the horizontal type, each being in a separate compartment. There are four cylindrical horizontal fire-tube boilers placed in two water-tight compartments. The engines are required to develop 4,800 H.P. under forced draft, with a corresponding speed of 17 knots.

LAUNCH OF THE "MAINE."

The armored cruiser *Maine* was launched at the Brooklyn Navy Yard November 18. She is the heaviest ship in weight of guns and armor so far launched for the Navy, and the first of the new fleet built in a Government yard. This vessel has been heretofore described in these columns, but a brief account will be repeated here, for convenience of reference.

The construction of the *Maine* was authorized in 1886, and the plans for the vessel were prepared in the Navy Department. As already stated, she has been built in the Brooklyn Navy Yard, the steel being furnished under con-

tract by Carnegie, Phipps & Company, of Pittsburgh. Work was begun two years ago, and the first keel-plate was laid October 11, 1888. She is an armored cruiser, having a water-line armor belt 12 in. thick, protecting the guns, machinery, and magazines, and extending for 180 ft. of the length of the ship. The general dimensions are as follows: Length over all, 324 ft. 4½ in.; length on load water-line, 318 ft. 3 in.; extreme breadth, 57 ft.; mean draft, 21 ft. 6 in.; displacement, 6,682 tons. She will have three masts, provided with fighting tops.

The main battery will consist of four 10-in. breech-loading rifles, mounted in barbette, with 12-in. steel armor protection to the barbette and 8-in. steel shields over the guns; six 6-in. breech-loading rifles, provided with segmental shields of 2-in. steel. The secondary battery will include four 6-pdr., eight 3-pdr., and two 1-pdr. rapid-five guns, four 37-mm. revolving cannon, and four Gatling guns. There will be also seven torpedo-tubes.

The *Maine* has two three-bladed propellers 15 ft. in diameter, each driven by a separate engine. These engines are of the vertical inverted cylinder, direct-acting, triple-expansion type, with cylinders 35½ in., 57 in., and 88 in. in diameter by 36 in. stroke. Working at full power, with 135 lbs. steam pressure, these engines will make 132 revolutions per minute, and are expected to develop 9,000 H.P. and to give the ship a speed of 17 knots an hour. Steam will be furnished by eight single-ended steel boilers, of the horizontal return-tube type, each 14 ft. 8 in. in diameter and 10 ft. long; the total grate area is 553 sq. ft. and the total heating surface 18,800 sq. ft. The engines and boilers are being built under contract by N. F. Palmer, Jr., & Company, of New York. These engines and boilers were described and illustrated in the JOURNAL for July last, page 305; they were designed by the Bureau of Steam Engineering in the Navy Department.

TRIALS OF NEW SHIPS.

The *Newark*, a cruiser very similar in plan to the *Charleston*, *Baltimore*, *Philadelphia*, and *San Francisco*, has had her preliminary trials, of which very favorable reports are made. The official trials were to be made in the latter part of November, but too late for the results to be reported here.

The gunboat *Concord*, one of the smaller cruisers, was also to have had her official trials in November. Like the *Newark*, excellent reports are made as to the preliminary trial trips made under charge of the builders. The *Bennington*, a sister ship to the *Concord*, will soon be ready for trial.

THE INTERNATIONAL RAILROAD CONGRESS.

THE questions to be discussed by the International Railroad Congress at its next meeting, which will be held in St. Petersburg in 1891, have been announced; they are as follows for the FIRST SECTION—Roadway and Buildings:

1. Nomenclature and Technical Terms; the establishment of an exact and uniform nomenclature.
2. Switches and Crossings.
3. Maintenance of Track; the best system for general adoption.
4. Work of the Wheels upon the Rails; determination of the limit.
5. Relation between Track and Rolling Stock.
6. Track for Fast Trains.
7. Control of the Speed of Trains.
8. Technical Reports; these include the information to be collected on (*A*) Breakage of Rails and Wear of Steel Rails; (*B*) Maintenance of Track with Metal Ties; (*C*) Life of Wooden Ties, both in natural condition and when treated by some preserving process.

The SECOND SECTION—Motive Power and Rolling Stock—will consider the following subjects:

9. Effect of Curves; the best way of providing for their easy passage.
10. Production of Steam.
11. High Boiler Pressures and Compounding.
12. Equipment for Light Railroads.
13. Continuous Heating of Passenger Trains.
14. Regulating Work of Locomotive Engineers; best system for utilizing the locomotives.
15. Technical Reports; these include (*A*) Fuel Consumption in Locomotives; (*B*) Boiler Tubes, best material, cost of maintenance, etc.; (*C*) Tires; (*D*) Lubrication of Locomotives; (*E*) Crank-axles; (*F*) Locomotive Fire-boxes, best material; (*G*) Locomotive Boilers; best material, etc.; (*H*) Lubrication of Cars; (*I*) Yard or Switching engines.

Questions 4, 5, 7 and 9 will be considered by the First and Second Sections in joint meeting.

The THIRD SECTION—Operation—has the following questions assigned to it:

16. Fixed Signals and the Block System.
17. Lighting of Signals.
18. Train Signals; communication between cars and locomotive.
19. Distribution of Empty Cars.
20. Exchange of Rolling Stock.
21. Co-operation in Expediting the Dispatch of Freight on the part of Station-agents.
22. Lines of Light Traffic.
23. Technical Reports; these include (*A*) Best Utilization of Stations; (*B*) Best Utilization of Cars.

Question 18 will be discussed by the Second and Third Sections together, and No. 22 by the Third and Fifth Sections.

The FOURTH SECTION—General Management—has the following subjects prepared:

24. Railroads in New Countries.
25. International Relations.
26. Variations of Gauge.
27. Tracks and Stations used in Common; regulation, and the division of expenses.
28. Division of Traffic and Joint Tariffs of Rates.
29. Movement of Passengers.
30. Slow Freights.
31. Arrangements for Mutual Benefit; relief of employés, pensions, etc.
32. Auxiliary Establishments; management of restaurants, hotels, etc.
33. Technical Reports; these include comparative results of operation on different lines, and cost of the unit of traffic—passenger-kilometer or ton-kilometer.

Questions 29 and 30 will be considered by the Third and Fourth Sections jointly.

The FIFTH SECTION is charged generally with the subject of Light Railroads, including the following questions:

34. Best Gauge for Light Railroads.
35. Steam Power for Light Railroads; especially for local lines or tramways.
36. Rolling Stock.
37. Special Forms of Motive Power; this will include electric railroads and motive power other than steam locomotives.
38. Systems of Management.
39. Legislation; comparison of the laws in relation to Light Railroads in different countries.
40. Light Railroads as Feeders; the use of local lines, tramways, etc., as auxiliaries to main lines; methods adopted by main lines to establish such feeders.

THE USE OF WOOD IN RAILROAD STRUCTURES.

BY CHARLES DAVIS JAMESON, C.E.

(*Continued from page* 451.)

CHAPTER XXIX.

HOWE TRUSS BRIDGES.

IN the accompanying plans, Plate 122 gives a design for a through bridge of 80 ft. span; Plate 123 is a through bridge of 88 ft. span, while Plate 124 contains a number

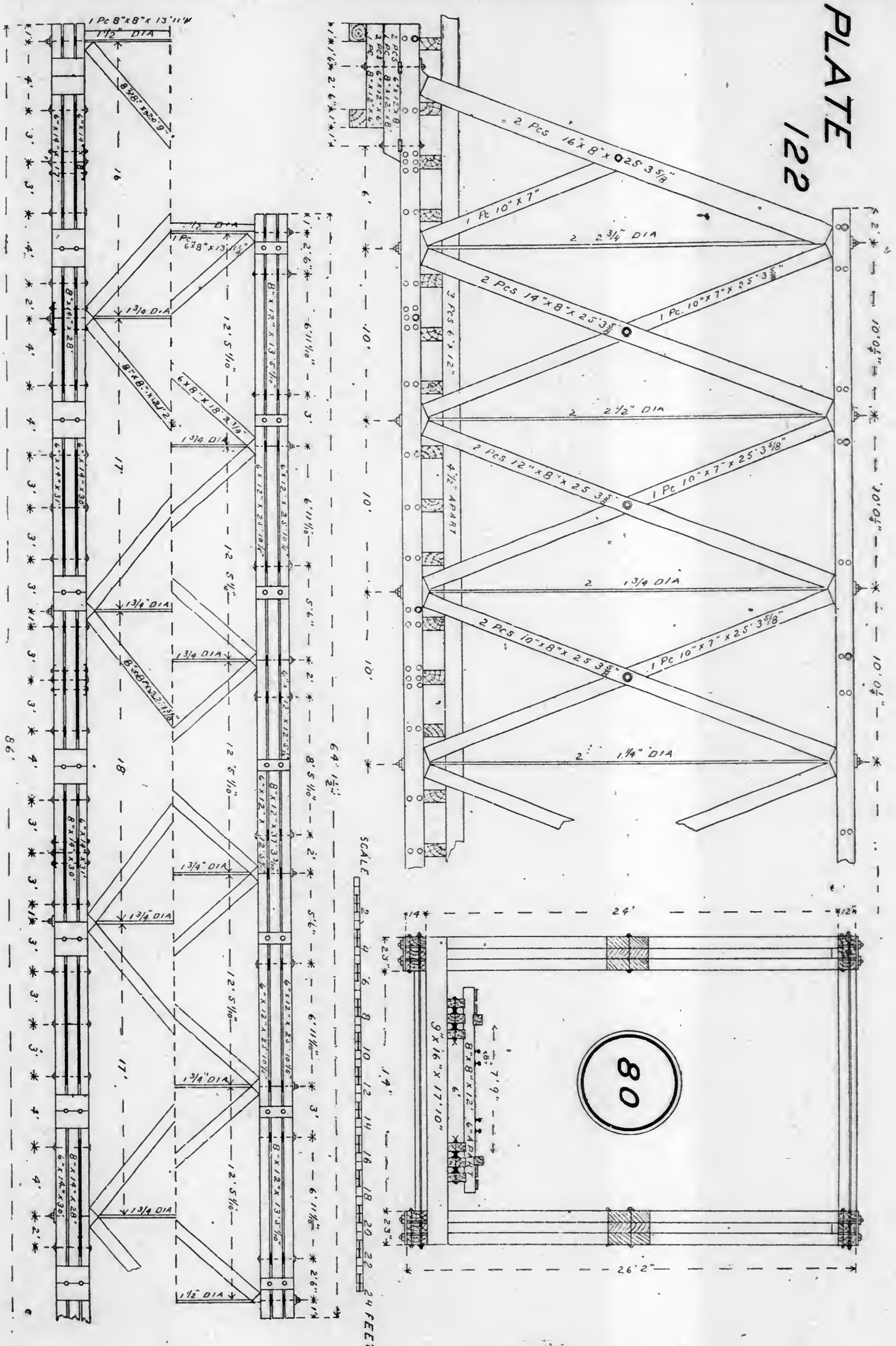


PLATE 122
80
SCALE
24 FEET

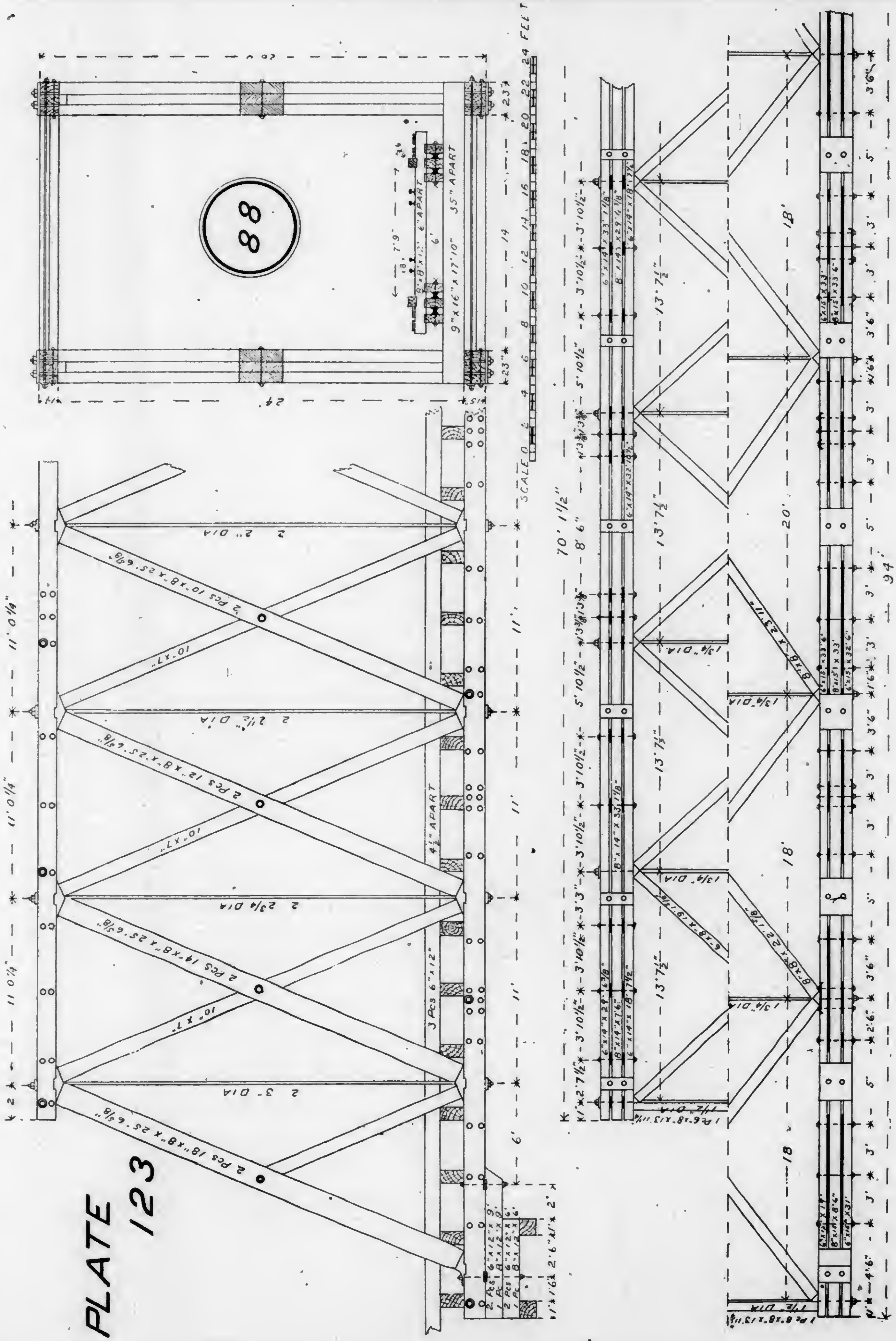
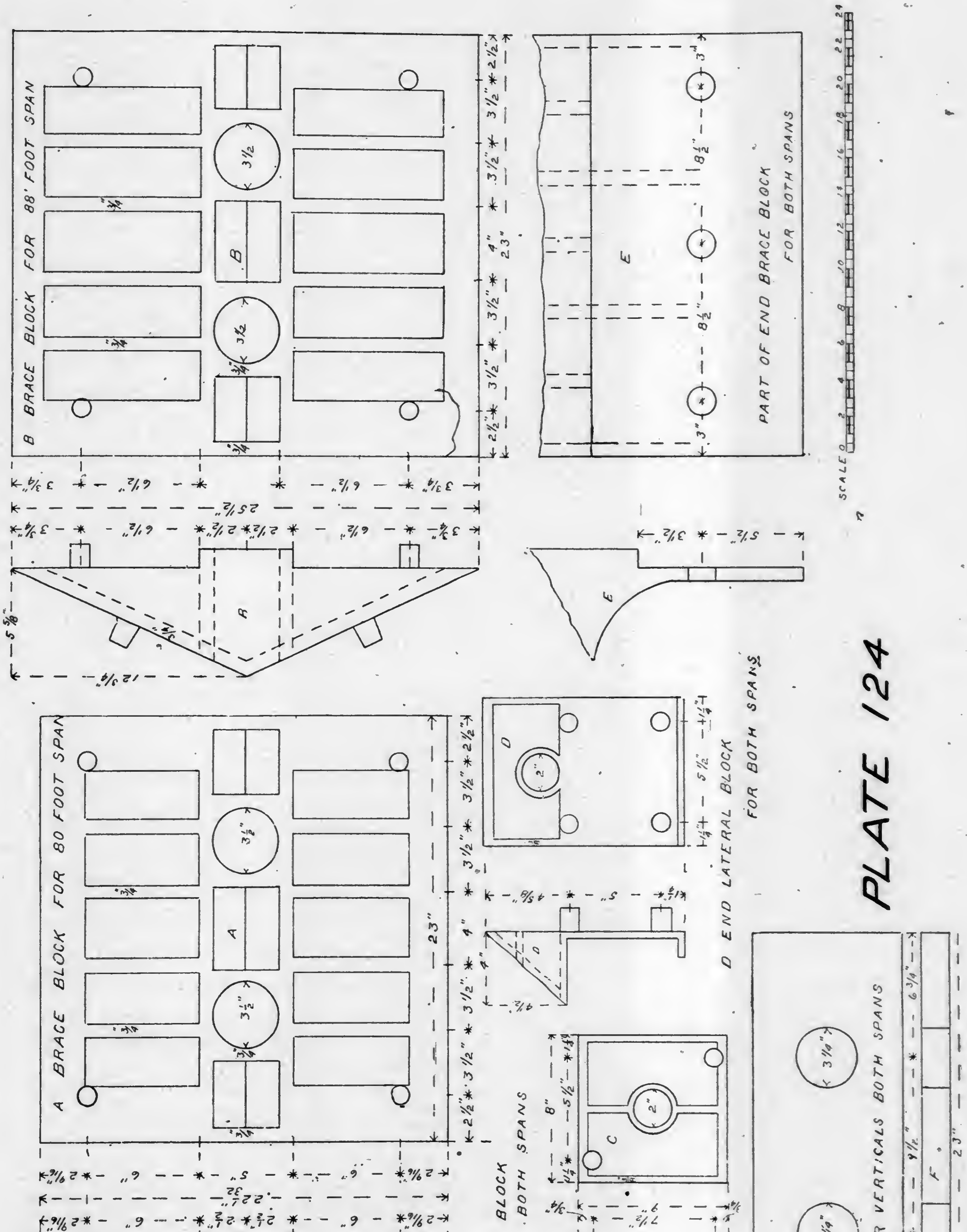


PLATE 123
88
SCALE 0 2 4 6 8 10 12 14 16 18 20 22 24 FEET
70' 1 1/2"
94'
2 Pcs 18"x8"x 25'-6 5/8"
2 Pcs 14"x8"x 25'-6 5/8"
2 Pcs 12"x8"x 25'-6 5/8"
2 Pcs 10"x8"x 25'-6 5/8"
3 Pcs 6"x12"
4 1/2" APART
35" APART
9"x16"x17'10"


B BRACE BLOCK FOR 88' FOOT SPAN
PART OF END BRACE BLOCK FOR BOTH SPANS
SCALE
FEET
A BRACE BLOCK FOR 80 FOOT SPAN
D END LATERAL BLOCK FOR BOTH SPANS
C LATERAL BLOCK FOR BOTH SPANS
F STRAP FOR VERTICALS BOTH SPANS
PLATE 124

of details common to both. Other details—castings, etc.—will be found on Plate 117, which was given on page 402, September number.

The bill of materials given herewith will, with the plates, give all that is necessary to understand fully the construction of the bridge.

No. 50. BILL OF MATERIAL FOR HOWE TRUSS BRIDGE. THROUGH SPAN, 88 FT. PLATES 123 AND 124.

Timber.

No. of Pieces.	Description.	Size.	Length.	Kind of Wood.
2	Top Chord......	6 in. × 14 in.	29 ft. 6⅜ in.	Yellow Pine.
2	" "	6 in. × 14 in.	33 ft. 1⅛ in.	" "
2	" "	6 in. × 14 in.	7 ft. 6 in.	" "
2	" "	6 in. × 14 in.	33 ft. 10½ in.	" "
4	" "	6 in. × 14 in.	18 ft. 7½ in.	" "
2	" "	8 in. × 14 in.	33 ft. 1⅛ in.	" "
2	" "	8 in. × 14 in.	29 ft. 6⅜ in.	" "
2	" "	8 in. × 14 in.	7 ft. 6 in.	" "
2	Bottom Chord......	6 in. × 15 in.	19 ft. 0 in.	" "
2	" "	6 in. × 15 in.	33 ft. 0 in.	" "
2	" "	6 in. × 15 in.	33 ft. 6 in.	" "
2	" "	6 in. × 15 in.	8 ft. 6 in.	" "
2	" "	6 in. × 15 in.	31 ft. 0 in.	" "
2	" "	6 in. × 15 in.	32 ft. 6 in.	" "
2	" "	6 in. × 15 in.	30 ft. 6 in.	" "
2	" "	8 in. × 15 in.	8 ft. 6 in.	" "
2	" "	8 in. × 15 in.	33 ft. 0 in.	" "
2	" "	8 in. × 15 in.	33 ft. 6 in.	" "
2	" "	8 in. × 15 in.	19 ft. 0 in.	" "
8	Braces..............	8 in. × 18 in.	25 ft 6⅝ in.	" "
8	"	8 in. × 14 in.	25 ft. 6⅝ in.	" "
8	"	8 in. × 12 in.	25 ft. 6⅝ in.	" "
8	"	8 in. × 10 in.	25 ft. 6⅝ in.	" "
12	Counters..	7 in. × 10 in.	25 ft. 6⅝ in.	" "
4	"	7 in. × 10 in.	14 ft. 0 in.	" "
10	Laterals.............	6 in. × 8 in.	19 ft. 1⅝ in.	" "
2	"	6 in. × 8 in.	13 ft. 11¼ in.	" "
8	"	8 in. × 8 in.	22 ft. 1⅝ in.	" "
2	"	8 in. × 8 in.	23 ft. 11 in.	" "
2	"	8 in. × 8 in.	13 ft. 11¼ in.	" "
8	Bolsters...........	6 in. × 12 in.	9 ft. 0 in.	" "
4	"	8 in. × 12 in.	9 ft. 0 in.	" "
8	Bridge-seats.........	6 in. × 12 in.	6 ft. 0 in.	" "
4	" "	8 in. × 12 in.	6 ft. 0 in.	" "
4	Sills................	12 in. × 12 in.	18 ft. 0 in.	Spruce or Pine.
26	Floor-beams.........	9 in. × 16 in.	18 ft. 0 in.	" " "
6	Stringers............	6 in. × 12 in.	94 ft. 0 in.	" " "
81	Ties................	8 in. × 8 in.	12 ft. 0 in.	Oak.
2	Guards.............	6 in. × 6 in.	94 ft. 0 in.	Spruce or Pine.
4	Planks.............	2 in. × 8 in.	94 ft. 0 in.	" " "
8	Blocks..............	2 in. × 8 in.	2 ft. 0 in.	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.......	3 in.	26 ft. 10 in.	12	Bolster b'lts	1¼ in.	2 ft. 5 in.
8	"	2¾ in.	26 ft. 10 in.	12	" "	1¼ in.	3 ft. 5 in.
8	"	2½ in.	26 ft. 10 in.	52	Fl.beam b'ts	1¼ in.	4 ft. 5 in.
4	"	2 in.	26 ft. 10 in.	64	String'rb'lts	¾ in.	2 ft. 6 in.
4	Laterals....	1½ in.	18 ft. 6 in.	54	Tie-bolts...	¾ in.	2 ft. 6 in.
8	" ...	1¾ in.	18 ft. 6 in.	54	G'rd-r'l-b'lts	¾ in.	1 ft. 3 in.
200	Chord-bolts.	¾ in.	2 ft. 0½ in.	24	Spikes...	½ in.	9 in.
16	Brace-bolts.	¾ in.	2 ft. 0½ in.				

Other Iron Work.

Washers (see Plate 117): 800 of pattern *G*; 200 of *H*; 24 of *H* 2.

Castings (see Plate 124): 28 of pattern *B*; 4 of *E*; 16 of *C*; 8 of *D*; 28 of *F*.

Castings (see Plate 117): 10 of pattern *F*; 128 of *I*; 156 of *L*; 48 of *M*; 24 of *N*; 24 of *O*.

NOTE.—The same packing blocks used for top and bottom chords.

No. 49. BILL OF MATERIAL FOR HOWE TRUSS BRIDGE. THROUGH SPAN. 80 FT. PLATE 122.

Timber.

No. of Pieces.	Description.	Size.	Length.	Kind of Wood
8	Top Chord..........	6 in. × 12 in.	25 ft. 10¼ in.	Yellow Pine.
4	" "	6 in. × 12 in.	12 ft. 5⅛ in.	" "
2	" "	8 in. × 12 in.	37 ft. 3⅜ in	" "
4	" "	8 in. × 12 in.	13 ft. 5⅛ i	" "
4	Bottom Chord......	6 in. × 14 in.	31 ft. 0 in.	" "
4	" "	6 in. × 14 in.	30 ft. 0 in.	" "
4	" "	6 in. × 14 in.	17 ft. 0 in.	" "
4	" "	6 in. × 14 in.	8 ft. 0 in.	" "
2	" "	8 in. × 14 in.	30 ft. 0 in.	" "
4	" "	8 in. × 14 in.	28 ft. 0 in.	" "
8	Braces	16 in. × 8 in.	25 ft. 3⅝ in.	" "
8	"	14 in. × 8 in.	25 ft. 3⅝ in.	" "
8	"	12 in. × 8 in.	25 ft. 3⅝ in.	" "
8	"	10 in. × 8 in.	25 ft. 3⅝ in.	" "
12	Counters....... ..	10 in. × 7 in.	25 ft. 3⅝ in.	" "
4	"	10 in. × 7 in.	13 ft. 8 in.	" "
10	Laterals............	6 in. × 8 in.	18 ft. 2¾ in.	" "
2	"	6 in. × 8 in.	13 ft. 11¼ in.	" "
4	"	8 in. × 8 in.	20 ft. 9 in.	" "
4	"	8 in. × 8 in.	21 ft. 2¼ in.	" "
4	"	8 in. × 8 in.	22 ft. 1⅝ in.	" "
2	"	8 in. × 8 in.	13 ft. 11¼ in.	" "
8	Bolsters..........	6 in. × 12 in.	8 ft. 0 in.	" "
4	"	8 in. × 12 in.	8 ft. 0 in.	" "
8	Bridge-seats........	6 in. × 12 in.	6 ft. 0 in.	" "
4	" "	8 in. × 12 in.	6 ft. 0 in.	" "
4	Sills...............	12 in. × 12 in.	18 ft. 0 in.	Spruce or Pine.
26	Floor-beams	9 in. × 16 in.	18 ft. 0 in.	" " "
6	Stringers	6 in. × 12 in.	86 ft. 0 in.	" " "
74	Ties...............	8 in. × 8 in.	12 ft. 0 .	Oak.
2	Guards.	6 in. × 6 in.	86 ft. 0 in.	Spruce or Pine.
4	Planks.............	2 in. × 8 in.	86 ft. 0 in.	" " "
8	Blocks..............	2 in. × 8 in.	2 ft. 0 in.	Oak.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods... ...	2¾ in.	26 ft. 10 in.	12	Bolster b'lts	1¼ in.	2 ft. 4 in.
8	"	2⅛ in.	26 ft. 10 in.	12	" "	1¼ in.	3 ft. 4 in.
8	"	1¾ in.	26 ft. 10 in.	52	Fl.beam b'ts	1¼ in.	4 ft. 4 in.
4	"	1¼ in.	26 ft. 10 in.	56	String'rb'lts	¾ in.	2 ft. 6 in.
4	Laterals....	1½ in.	18 ft. 6 in.	48	Tie-bolts.	¾ in.	2 ft. 6 in.
8	" ...	1¾ in.	18 ft. 6 in.	48	G'rd-r'l-b'lts	¾ in.	1 ft. 3 in.
192	Chord-bolts.	¾ in.	2 ft. 0½ in.	2	Spikes......	⅛ in.	9 in.
16	Brace-bolts.	¾ in.	2 ft. 0½ in.				

Other Iron Work.

Washers (see Plate 117): 750 of pattern *G*; 160 of *H*; 24 of *H* 2.

Castings (see Plate 124): 28 of pattern *A*; 4 of *E*; 16 of *C*; 8 of *D*; 28 of *F*.

Castings (see Plate 117): 10 of pattern *F*; 112 of *I*; 56 of *K*; 108 of *L*; 44 of *M*; 22 of *N*; 22 of *O*.

The kind of timber used may be changed when necessary, though that given is considered the best.

(TO BE CONTINUED.)

ARMY ORDNANCE NOTES.

THREE bids were opened at the War Department in Washington, November 13, for supplying armor-piercing projectiles for the steel guns now being made for sea-coast defense. The requirements for these projectiles are somewhat strict. The 10-in. shot will weigh 570 lbs. and must pierce a steel plate 11.2 in. thick when fired with a muzzle velocity of 1,625 ft. per second, without being cracked or materially deformed. The 8-in. shot must pierce a 9-in. plate under the same conditions. The bids were as follows :

1. Carpenter Steel Company, Reading, Pa., 8-in. shot, $150 each ; 10-in. shot, $285 each.

2. Midvale Steel Company, Midvale, Philadelphia, 8-in. shot, $150 ; 10-in., $287.

3. Sterling Steel Company, Pittsburgh, Pa., 8-in. shot, $300 ; 10-in., $575.

The Carpenter Steel Company, it is said, has secured the right to make these shells under the Firminy process in use in Europe, but declines to make public any details. The Midvale Company has a process of its own, which is also kept secret. The Sterling Company also has a process of its own, and intends to use crucible steel made from Dannemora iron. It will be noticed that its bid was almost exactly twice that of either of the other companies.

THE REPORT OF THE ORDNANCE BUREAU.

In his yearly report to the Secretary of War, General S. V. Benet, Chief of the Bureau of Ordnance, says that while extensive experiments have been carried on abroad with smokeless powders, and some astonishing results have been obtained, yet difficulties have been developed which still make it uncertain whether these will replace the present service powder. The Department has so far been able to procure only very small samples, and while some experiments have been made with them in small arms, the lack of a sufficient quantity has prevented the perfecting of all the details of the new 0.30-caliber rifle ; but as soon as possible the work will be continued.

It is recommended that a Board be appointed to select a suitable mechanism for a magazine rifle to replace the present Springfield rifle.

The appropriation for the gun factory at the Watervliet Arsenal has been expended and the work of completing the plan to give an output of 24 heavy guns yearly is well advanced.

Work under the contracts with the Pneumatic Dynamite Gun Company has progressed slowly. Most of the materials for the guns intended for New York and Boston have been procured, but work on the guns intended for San Francisco has not been commenced.

The plans of the Fortification Board included the manufacture of 44 of the new 16-in. seacoast guns, 36 of them to be used in the three ports of New York, San Francisco, and Boston. These guns are to be mounted in pairs in turrets so placed as to command the principal water approaches of the port. The total length of the proposed 16-in. gun is about 49 ft. 6 in.; the length of the bore 35 calibers, and the weight 125 tons. One of these guns will have a charge of about 1,000 lbs., with a projectile of over one ton in weight. The estimated muzzle penetration in iron is about 3 ft. and the maximum range 15 miles.

Among the appropriations asked for are $125,000 for steel forgings for one type sea-coast gun of 16-in. caliber ; $325,000 for carriages for 12-in. mortars ; $200,000 for armor-piercing projectiles ; $1,250,000 for steel for 8-in., 10-in., and 12-in. guns ; $708,743 for the new south wing at Watervliet Arsenal and for cranes and other tools for the same.

THE GOVERNMENT SURVEYS FOR THE GREAT SIBERIAN RAILROAD.

By A. Zdziarski, Engineer.

As was stated in the July number of the Journal, it was decided in 1887 by the Commission of four Ministers then appointed to order the survey of four lines :

1. The Central Siberian Railroad, from Tomsk to Irkoutsk.

2. The Trans-Baikal, from Lake Baikal or some point on its tributary, the Selenga River, to some point on the Amour River or its tributary, the Shilka.

3. The Oussouri Railroad, from the Oussouri River to Vladivostok.

4. The Baikal Loop Line, around Lake Baikal either to the north or to the south, connecting lines 1 and 2.

Concerning the traffic capacity of the Great Siberian Railroad, the Commission considered it sufficient that it should be designed for running three trains daily in each direction, at a speed of 16 miles an hour, the road, however, to be so constructed that the number of daily trains could be increased to seven without difficulty.

As the line will traverse a country of very varying topography, the technical conditions and specifications were ordered to be of two kinds : for plain or level sections and for mountain sections. For level sections the ruling gradients are fixed at 0.8 per cent. and the minimum radius of curvature 1,750 ft.; the weight of rails to be 54 lbs. Russian (49 lbs. English) to the yard. For the mountain sections the ruling gradient was fixed at 1.5 per cent., exceptional sections to be 2 per cent. The minimum radius of curvature was placed at 1,050 ft., 840 ft. to be permitted in exceptional cases, provided that the sharpest curvature and the heaviest grades should not come together ; the weight of rails to be 60 Russian lbs. (54½ English lbs.) to the yard.

The other specifications were made similar to the standard requirements of the Russian State Railroads, but with some relaxation. The gauge, of course, was fixed at the Russian standard of 5 ft. The width of grade was to be at least 14.4 ft.; the length of ties, 8 ft., and the quantity of ballast at least 2,300 cub. yds. per mile. The bridges might be of wood unless, according to local conditions, iron and masonry would be cheaper ; for the large rivers, such as the Yenesei, steam ferries might be used instead of bridges.

These conditions, which were elaborated by the State Railroad Direction, were endorsed by the Commission of Ministers, and were made part of the instructions given by the Minister of Roads and Communications to the Chief Engineers of the three expeditions, which were appointed to make the surveys of the different lines. The cost of these three surveys was estimated as follows :

Line.	Cost of Survey in Roubles.	
	Total.	Per Mile.
Central Siberian Line	225,000	200
Trans-Baikal Line	157,000	215
Oussouri Line	120,000	450
Total	502,000	....
Reconnoissance of Baikal Loop Line	12,000	....

After the instructions had been confirmed and the money credit allowed, the following Chief Engineers were appointed for each expedition : N. P. Mejeninov, C.E., for the Central Siberian Railroad ; O. P. Viazemski, C.E., for the Trans-Baikal Line ; and A. O. Oursatti, C.E., for the Oussouri Railroad. The surveys for the Central Siberian and the Oussouri Lines were made in the years 1887–88, and for the Trans-Baikal Line in the years 1888–89.

After this preliminary general statement the results of the work of each expedition will be given separately.

I.—THE CENTRAL SIBERIAN RAILROAD.

According to the instructions given, the general location of this line started from Tomsk on the river Tom, a tributary of the Obi, and following more or less closely the present post road, passes through Mariinsk, Achinsk, Krasnoiarsk, and Kansk to Irkoutsk. The location is shown on the accompanying map ; the general situation of this section may be seen on the map of Siberia published in the June number of the Journal, page 259.

The whole length of this line from Tomsk to Irkoutsk is 1,038 miles, or 1,048 miles including branches to the river ports or landings.

In consequence of the varying character of the country, it was necessary to divide this line into five sections, as follows :

1. From Tomsk to Achinsk, 256 miles.
2. From Achinsk to Krasnoiarsk, 115 miles.
3. From Krasnoiarsk to Nijne-Oudinsk, 355 miles.
4. From Nijne-Oudinsk to Oukhtouisk, 158 miles.
5. From Oukhtouisk to Irkoutsk, 164 miles.

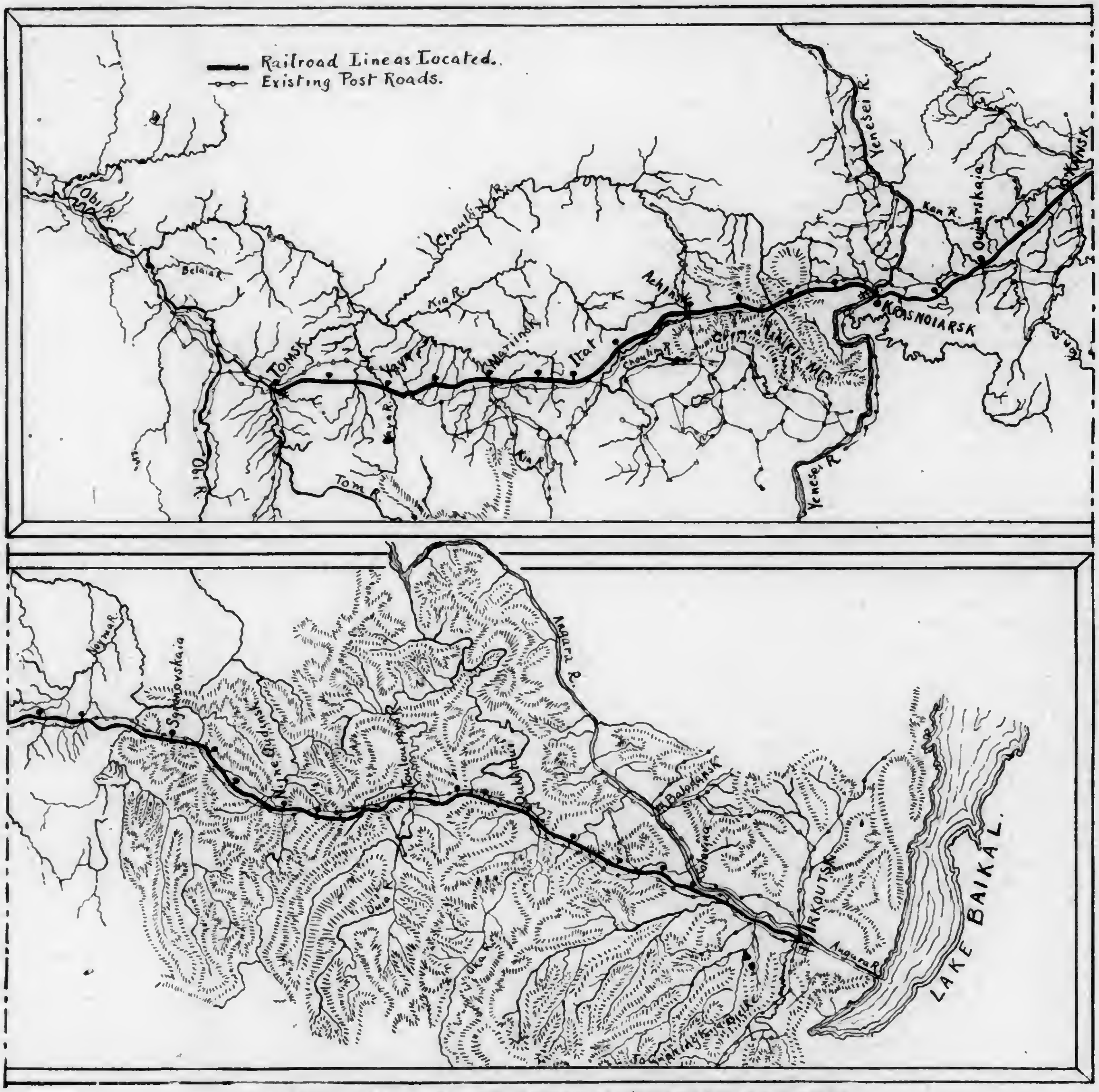
Of these sections the first and fourth are level, the second and third mountain sections, while the fifth runs

through a mountain country from Oukhtouisk to Polovinnaia, but from that point to Irkoutsk is level.

On this line it was arranged to make the greatest distance between water stations 19 miles, which, with an average speed of 16 miles an hour, would permit the running of seven daily trains each way ; but the sidings or passing places at present are placed 33 miles apart, permitting the running of three trains only each day. In case, however, more trains should be needed, additional sidings can easily be put in.

The level sections have the ruling grade 0.8 per cent and of 1.5 per cent. and minimum radius of curvature 1,050 ft. —were applied to the sections from Achinsk to Krasnoiarsk ; from Krasnoiarsk to Nijne-Oudinsk, and from Oukhtouisk to Polovinnaia, making a total of 503 miles, all in very rough mountain country. At each end of each of these sections is located a division station with engine-houses. The Yenesei River is crossed near Krasnoiarsk.

The location of the line from Achinsk to Irkoutsk was very difficult, since the line, following a general direction to east and southeast, was obliged to cross the ridges or



LOCATED LINE OF THE CENTRAL SIBERIAN RAILROAD.

the minimum radius of curvature 1,750 ft., although at some points the gradient was increased to 0.9 per cent., but on this grade the minimum radius of curvature was not in use. This condition satisfies the requirement that a train of 30 freight cars, weighing about 300 tons, can be hauled by one standard 36-ton engine.

The first section from Tomsk to Achinsk, as already stated, was a level section, but the branch extending from the Tomsk Station to the port or landing on the Tom River has grades of 1.5 per cent., with curves of 840 ft. and 1,050 ft. radius.

The conditions of the mountain sections—limiting grades ranges dividing the valleys of the Siberian rivers, which here all flow from the Saian Mountains, and run northward in the same direction as the ranges of hills which separate them. On this part of the line there are 15 of these divides, some of them rising to a height of 980 ft. above the valleys.

While the grade of this section was designed for single track only, the road-bed is made in open country 16.8 ft. in width ; in wet or marshy lands 18 ft., and in cuts 15.4 ft.

The average quantity of earthwork required is estimated at 35,500 cub. yds. per mile.

A distinguished feature of the Great Siberian Road is the great number of river crossings required. The line will cross the following, which may be called great rivers, requiring bridges of lengths varying from 175 ft. to 1,400 ft.: The Kitat, a tributary of the Yaya; the Yaya and the Kaya, tributaries of the Chulim; the Chulim, a tributary of the Obi; the Great Kemchoug, a tributary of the Chulim; the Kacha, a tributary of the Yenesei, which is ¾ mile wide at the crossing; the Little Ouria and the Great Ouria, tributaries of the Kan; the Kan; the Poija, the Reshety and the Koutorka, tributaries of the Birusa; the Birusa, a tributary of the Yenesei; the Kamenna, the Poganka, and the Ouda, tributaries of the Chouna, which belongs to the Yenesei system; the Kourzam, a tributary of the Ouia; the Ouia, the Oka, the Zalaria, the Balaia, and the Kitoi, all tributaries of the Angara, which is the outlet of Lake Baikal, flowing from that river and falling into the Yenesei.

The bridges over these rivers are all designed to have iron superstructure and masonry abutments and piers. Masonry will be necessary in view of the thickness of the ice which forms upon the rivers in Siberia, but in the beginning the superstructure of some of them may be of wood. The smaller bridges and viaducts or trestles will also be built of wood, the intention being to use wooden structures with masonry abutments. In some cases cast-iron culvert pipes of 3½ ft. diameter will be used, and there will also be a number of masonry culverts from 7 ft. to 14 ft. span. No less than 40 caisson foundations will be required.

The number and sizes of the iron bridges will be as follows:

No.	Kind of Bridge.	Span.	Total length.
3	Deck truss spans................	70 ft.	210 ft.
6	Through truss spans..............	70 "	420 "
2	Through truss spans..	84 "	168 "
2	Deck truss spans..................	105 "	210 "
3	Deck truss spans..................	140 "	420 "
10	Deck truss spans..................	175 "	1,750 "
29	Through truss spans..............	175 "	5,075 "
3	Through truss spans.....	210 "	630 "
5	Through truss spans.....	245 "	1,225 "
10	Through truss spans..........	280 "	2,800 "
73	....	....	12,908 ft.

The 10 spans of 280 ft. are designed for two bridges, each of five spans, one over the Kan River and the other over the Birusa. The total weight of iron required for the superstructure of all the bridges will be 15,000 tons.

The bridge over the Yenesei will require 11 spans of 350 ft. each, but it is not included in the table above because the intention is for the present to use a steam ferry, which, it is believed, will be more economical and will cost about 600,000 roubles.

As noted above, there will be required 2,300 cub. yds. of ballast per mile, and the ties will be 8 ft. in length; they will be cut and delivered along the line by teams. The total length of sidings will be 7½ per cent. of the length of the main track. As the rails are somewhat light—54 lbs. Russian, or 49 lbs. English, to the yard—a large number of ties will be used, the estimate being for 2,446 per mile.

The smaller buildings of the road will be constructed, as is very common in Siberia, of wood, with foundations of wooden crib work. The track watchmen will be stationed two miles apart and the section-men at convenient distances, so that there will be required 525 watchmen's houses and 273 section-houses. There will be in all 69 stations built of the type generally adopted on the State Railroad, three being rated as of the second class, 12 of the third, 24 of the fourth, and 30 of the fifth class. The greatest distance between stations on level sections is 19 miles, and on mountain sections it is 17½ miles. As the six-wheel or passenger locomotives have a tender capacity of 300 cub. ft., and the eight-wheel or freight locomotives of 400 cub. ft. of water, this will be sufficient. For the present at the fifth-class stations there will be provided only water tanks, but no sidings. The latter will be put in as the traffic increases sufficiently to require it.

The station buildings will be of wood, placed on masonry foundations and with sheet-iron roofs. The house for officers and employés will be also of wood on masonry foundations. There will be three separate freight stations, one in Tomsk, one in Krasnoiarsk, and one in Irkoutsk.

There will be 15 engine-houses of quadrangular form, and it is calculated that four-fifths of the engines will be in the engine-house at one time. In consequence of the cold climate of Siberia the engine-drivers will not run more than 100 miles at a time, and it will also be necessary to have the houses well heated. The repair shops at present will be on a small scale. They will be of masonry, with sheet-iron roof.

As to water-supply, suitable sources, as lakes, rivers, springs and wells, are found in abundance at every point where it is needed. In order to prevent difficulty from freezing, the conducting pipes have to be placed at least 10½ ft. deep and covered with ashes, birch bark, or some other poor conductor of heat. The standard water tank is of boiler plate, having a capacity of 3,072 cub. ft., and they are to be placed with the bottom elevated at least 21 ft. above rail-level. At each engine-house there will be a tank with double the ordinary capacity, and hydraulic and other cranes will be placed where needed.

There will be 15 turn-tables of the Sellers pattern at the 15 principal stations. These will be 55 ft. in diameter, and there will also be required five small turn-tables for cars and three weighing bridges. The station yards will be supplied with the necessary sidings, switches, and signals, but will not be generally paved or fenced, except at the principal points.

The cost of the Central Siberian Line, 1,048 miles in all and not including the Yenesei Bridge, is approximately estimated at 68,680,000 roubles, or 65,534 roubles per mile. This is equivalent to about $35,000 per mile, which does not seem a large estimate in view of the great amount of mountain work and the fact that much of the material will have to be conveyed long distances.

(TO BE CONTINUED.)

STEAM-HEATING OF PASSENGER TRAINS ON THE PENNSYLVANIA RAILROAD.

(Paper read before the Franklin Institute, Philadelphia, by Mr. Theo. N. Ely, General Superintendent of Motive Power, Pennsylvania Railroad.)

SEVERAL requests have been made for a description of the passenger-car steam-heating system with which the Pennsylvania Railroad has been experimenting.

Much attention has been given to the broad question of car heating by water and steam for several years, and the process of elimination has confirmed the belief on our part that the return system is the one which must finally prevail if the best results are desired; whether the arrangement which is now being applied to the cars of the Pennsylvania Railroad is the best that can be devised can only be determined by a longer service than has yet been possible.

Briefly, a return system is one which, by the aid of a pump or other vacuum-producing device, brings back to the tender of the locomotive the water of condensation derived from the steam which has given up its heat in warming the cars.

In the Pennsylvania system—see diagram given herewith—an ordinary pump is used as a means of obtaining the necessary vacuum, and is located conveniently on the inside of the tender.

The steam to supply the system is taken from the bridge-pipe of the locomotive and passes into a reducing valve *A* where the pressure is reduced to about 40 lbs.; it then crosses over to the tender by means of a hose-pipe and enters a second reducing-valve *B*. The first of these valves is set to protect the hose-pipe, the latter to protect the train from extreme pressure.

Before the steam enters this second reducing-valve, a branch is taken off to drive the pump *C*, and on the other side of the valve the exhaust steam from the pump connects, so that this steam may be turned in to heat the train.

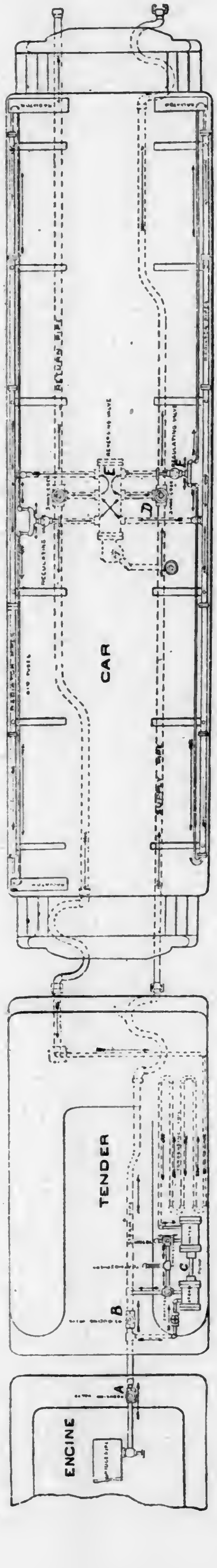


DIAGRAM OF STEAM-HEATING ARRANGEMENT, PENNSYLVANIA RAILROAD.

Leaving the second reducing-valve, the supply-pipe runs to the back of the tender and here crosses over and connects with the main supply-pipe under the car; this pipe runs the entire length of the car and connects to the next car, and so on, forming, when the train is coupled up, a supply-pipe running the entire length of the train.

In the center of each car a branch leaves the main pipe to supply the car with steam; at this point a three-way cock *D* is placed on the main pipe and arranged so as to allow the steam to flow along the main pipe and into the branch at the same time; this is the same in all of the cars, except the last, where it is turned in such a position as to allow the steam to flow into the branch pipe only, further communication back of this on the main pipe being cut off. This cock is operated from the inside of the car, and obviates the necessity of placing a cock at each end of the pipe, which cock when closed, as in the case of the rear of the last car, forms a pocket in which the condensed water may freeze; the main pipes leading through this three-way cock have a pitch to either end, and are so arranged that when uncoupled they will drain themselves. This branch pipe conducts the steam to a reversing valve *E*, which will be explained later on; by means of this the steam is distributed to both sides of the car, the two pipes conveying this steam coming up through the floor on opposite sides of the car and connecting with regulating-valves *F* placed to control the heat; these two valves stand, one on either side of the aisle, under the center of the seats, and are very easily operated without disturbing passengers.

The arrangement of radiators, pipes, etc., inside the car on both sides are exactly the same, both sides being operated independently, so that in case of a leak it is only necessary to shut the steam off one side.

The regulating-valve is the highest point reached, the pipes being so arranged that any condensed water that may accumulate will find its way out when the cars become uncoupled. From the regulating-valve, the steam is conducted by a $\frac{3}{4}$-in. pipe to the radiators, which are located in the corners of the car, and from them back to the center, by means of a cast-iron radiator-pipe 2 in. wide, 4 in. high, with radiating ribs 1 in. apart; these pipes are bolted together in lengths of about 6 ft.

In the center length of the cast-iron pipe, the exit for the condensed water is placed; this is a foot lower than the regulating-valve, so arranged that all the water condensed in the radiators, etc., will find its way to this point.

A piece of 2-in. wrought-iron pipe, capped, is screwed into the cast-iron radiator-pipe under each seat to give additional heating surface; the object is to condense as much of the steam in the radiators as possible, and this is done by throttling the exit from the cast-iron pipe. The two exits are connected with the reversing valve by two pipes which go through the floor and are brought by the reversing-valve again into one pipe. The arrangement from this point is the same as in the supply-pipe—namely, the pipe leaving the reversing-valve connects with a three-way cock situated on the main return-pipe, which runs the entire length of the car, and on the ends of which the couplings are placed, forming again when coupled a main return-pipe running the length of the train; the object of the three-way cock here is the same as in the former case, and it is operated from the inside of the car.

This return-pipe connects with the suction end of the pump, so that all of the condensed water is so drawn out of the system into the return-pipe, which conducts it to a condensing coil in the tank, to insure all of the steam being condensed before entering the pump; after passing through the pump it is discharged into the tank.

Reference was made some time back to a reversing-valve *E*; the conclusion that will have been drawn from the foregoing is that there are two main pipes under each car, one a supply, the other a return.

Should a car or train be reversed, the pipes will change places—that is, instead of having the supply-pipe on the left-hand side, it will be on the right-hand side; the object of the reversing-valve is to obviate this difficulty, and it is so arranged that by a simple movement, from inside the car, the pipe that was performing the duty of a supply will now perform the duty of a return. Another important

feature of this valve is that by further movement a connection is made with the exit from the radiator-pipes to the atmosphere, thereby changing the system to a direct one; the advantage of this is that, in the event of the pump failing, it would be the work of a minute to set the valves for the direct steam. Again, should it be necessary to couple one of these cars to a train fitted with the direct system, it would work equally well. The couplings used are what may be termed as "male and female," and so arranged that one of the same kind is on opposite diagonal corners of the same car; the male coupling is attached to the main pipe by means of a rubber hose-pipe in the form of an S in a horizontal plane, which allows for all of the movements between the cars, while the female is screwed on the main pipe on the opposite side.

The male coupling has placed on it a spiral spring enclosed in a case, movable on a longitudinal direction; upon this case are placed two trunnions; the female coupling has fastened to its end a joint ring for making it tight against the end of the male coupling; upon it are also placed two trunnions which serve as the hinges for the latch. This latter consists of a forked bell-crank fulcrumed upon the trunnions, and has its short arms furnished with recesses arranged to engage with trunnions on the male coupling.

When two cars are brought together, the latches are thrown back and male and female couplings brought end to end; a movement of the latch in opposite directions causes the recesses on the short arms of the latch to engage with the trunnions on the male coupling, the two arms brought tight against each other, and in so doing the spiral spring is compressed, which allows for small variations in length of the couplings, and insures the same pressure between their faces.

The long arm of the latch is fastened by means of a chain to the platform of the car upon which the male coupling is placed, and this chain is made of such length that when the cars are uncoupled, it will pull the latch over and release the steam coupling.

The operation of the system is clearly indicated by the arrows of the diagram.

The problem of heating a train on a cold day is a simple one as compared with that of heating a train on a mild day. It will be understood that the direct system requires steam at some pressure for distribution, and so in the pipes there can never be a temperature of less than 212°.

With such a temperature on a mild day it is difficult to regulate the temperature of the cars. The Pennsylvania Railroad Company has arranged the system so that in mild weather only the exhaust steam from the pump is used; the pump creates a vacuum, and this exhaust steam passes through the system in the form of a vapor, making it comparatively an easy matter to maintain the temperature at not more than 1° above the atmosphere, if necessary.

The pressure in the radiator-pipes, etc., inside the cars, varies from zero to one-half pound; this latter pressure is required in the coldest weather only.

It is, therefore, obvious that in case of accident there would be absolutely no danger from escaping steam.

The following data, taken from several trains running part of last winter, will indicate the general condition of service:

Average pressure on supply pipe	2.5 lbs. per sq. in.
" pressure in radiator-pipes	zero.
" vacuum	23 in.
" temperature outside	32°.
" temperature inside cars	70°.
" number of cars	5.

When it is necessary to heat a train quickly, the pump is started and a pressure of 20 lbs. is turned into the train-pipe; this will raise the temperature 15° to 20° every five minutes.

When the car becomes warmed to the required temperature, the pressure is reduced to the normal working.

Cars when once heated are found to retain their heat for considerable time. Ten minutes before the train arrives at its destination, it is usual to shut off all the steam from the train; the pump is kept going to draw all the water out of the system, so that when the couplings are undone, there are seldom more than a few ounces of water to come out.

In connection with the heating, much care has been given to secure ventilation, and with the following simple arrangement excellent results have been obtained.

Beneath the cast-iron radiator-pipes are placed a series of air-tubes, one under each seat; these make a connection with the outside air through a 2-in. opening. The hot air rising from the radiator-pipes naturally draws the fresh air in from these tubes, which becomes heated, and rising up passes out through the deck ventilators, inducing a current of warm, fresh air, which is made to pass through the car at all times.

An experiment was made with a train of 12 cars, and most favorable results were obtained, clearly demonstrating that the system is quite capable of heating any train running, or that would be likely to run.

In the return system, the steam taken from the boiler does not seem to affect the steaming of the locomotive; considerable trouble has been experienced in this respect, when using the direct system with heavy trains.

During the winter of 1889–90, 70 cars were put in use and performed satisfactory service.

There are a number of constructive details of the system described which can undoubtedly be simplified, as more experience is gained from actual operation.

THE SUBMARINE MINE AND TORPEDO IN HARBOR DEFENSE.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

I.—EARLY DEVELOPMENT.

Although the War of the Rebellion was fought in large measure, on both sides, with half-trained armies, with improvised navies, and, in many directions, with makeshift material, it nevertheless taught more lessons of practical military value than any war that has occurred in many generations.

Not the least among these lessons was that of the value of torpedoes or submarine mines in the defense of a harbor or seaport. In fact, so important a factor did these contrivances become that, so far at least as the Confederates were concerned, they passed from the ordinary rôle of subordinate or auxiliary to that of chief means of defense.*

It would not, of course, be true to say that the submarine mine had its birth during the Civil War. On the contrary, the resort to auxiliary means of defense against an enemy's ships is as old as human history, for the modern torpedo or mine has its prototype in the fire-ships of the Greeks and Romans, and is used precisely for the same purpose. Later on, when gunpowder came into general use, mine ships and powder boats were substituted for destroying the ships or damaging the defensive works of an adversary. But up to the time mentioned, the use of all such contrivances had been marked with but indifferent success, and, it may be added, the use of hidden mines was generally considered, along with chainshot, explosive bullets, etc., as barbarous and unworthy of civilized nations.

The American Revolution brought forward, in the person of David Bushnell, the pioneer in submarine mining, or rather the first inventor who seems to have understood the part played by water-pressure in calculating the effects of subaqueous explosions. He devised a submarine boat and a number of mines, floating and otherwise, but achieved no practical results—the attempted and almost successful demonstration against a British sixty-four, off Governor's Island, being the nearest approach to success he attained.

Robert Fulton and Samuel Colt both did much toward the development of torpedo warfare; both gave time and money freely in pushing their inventions; both received Government appropriations to enable them to carry on ex-

periments. But Government support failed in the end, and researches in this direction were abandoned—the one turning his attention to the steamboat, the other to the manufacture of fire-arms.

During the Crimean War the Russians, for the defense of their Baltic and Black Sea ports, used submarine mines extensively, but they were too small in size (usually charged with 20 lbs. of gunpowder) to do much actual damage, although the moral effect was sufficient to secure a number of their ports against attack by the allied fleet. In fact, in every great war since the beginning of the century, wherein maritime people have been involved, efforts have been made to utilize the submarine mine for defense, but the means and material at hand have been so inadequate to meet the exacting conditions their effective employment imposes, that it is very certain no great success could have been attained even had they been brought to the test of battle.

As a means of defense, mines have, of course, always had a value, but it was not until slow sailing craft, dependent on wind and tide, had given place to swift steamers, and later on to the modern armored fighting ship, of high speed, and practically invulnerable to fire delivered against her under existing conditions, that the necessity became imperative for some means of holding an enemy at a distance, at arm's length, so to speak, long enough to bring into effect the full artillery power of the defense.

This is the rôle of the submarine mine and the torpedo. So important have they become that no arrangements for the defense of a harbor or water-way is now considered complete without a system of mines. But to properly put down and care for such a system requires careful preparation in the beginning, and constant and vigilant supervision afterward, as well as provision for its certain operation in the hour of need. Such devices must always be subordinate to guns on shore, for if left to themselves, an enterprising enemy can always, with the means now at hand, neutralize or destroy them with little danger to himself.

II.—HOW CLASSIFIED.

As used in a military sense, the general term of torpedo was formerly employed to designate all explosive devices designed to act destructively against an enemy. As at present understood, this term applies to all *offensive, movable* contrivances of this kind. Those that are stationary and defensive are designated as mines, or submarine mines, where used in harbor defense.

Submarine Mines are divided into two general classes—Automatic and Controllable, which terms indicate with sufficient clearness the distinctive features of each.

An *Automatic, or Self-acting Mine* can only be fired by contact, and when once placed in position and rendered active by the removal of its safety-pin or plug, is entirely beyond control, and acts only when struck with sufficient force to set its igniting device in motion. Such a mine may be either *mechanical* or *electrical.* If mechanical, it is provided with some device for mechanically igniting its charge, as a falling weight, either within or without its case; a released spring actuating a hammer, or by a chemical fuse rendered active by concussion. If electrical, a small battery is used, which may be enclosed within the mine itself, within its anchor, or placed upon the bottom some distance away. The blow from a ship or a heavy body is made to close the firing circuit and ignite the fuse.

A *Controllable Mine* is one provided with proper electrical apparatus, and is always under absolute control. Such a mine may be set to be exploded automatically on contact with a vessel, or at will from the shore, and can at any time be rendered harmless by cutting out the firing battery. It possesses the further great advantage that it can be tested and its condition ascertained at any time.

An *Automatic Mine* has the advantage of being easily constructed and planted; it can be prepared beforehand, put in store and placed in position when needed, and its manufacture and manipulation does not require skilled labor. On the other hand, when once in position it bars a harbor against friend and foe alike; it is more or less dangerous to handle, and there is no method by which it can be tested and its condition ascertained.

As to the manner of mooring, a further division is made into *Ground* and *Buoyant* mines—their names indicating that the one is placed upon the bottom of the channel, serving as its own anchor, while the other, by means of an anchor and a connecting cable, is made to float at any required distance below the surface.

Torpedoes are of two general classes—Uncontrollable and Controllable. As its name indicates, the latter class includes every torpedo which when once put in motion passes entirely beyond the control of the operator. It may be fired from a gun like a projectile; from a tube like a rocket; may be sent to drift against its object with tide or current, or carry within itself the mechanism necessary for its locomotion.

A Controllable torpedo is one that maintains during its entire course mechanical or electrical connection with the operating station, and is under complete control of the operator. It may be attached to a spar and thus directed against its object; may be towed on divergent lines by a boat or vessel, or be driven on its course by power supplied from the sending station by an electric cable or by mechanism contained within itself. In either case its course is directed from the shore.

III.—AS USED BY THE CONFEDERATES.

As marking an epoch not only in the growth of the torpedo and of its employment upon a large scale in actual warfare, but also as having led to great modifications in the art of shipbuilding as applied to war ships, and in view of the influence it exerted upon the conduct of the war, the means employed, and the results obtained by the Confederates seem to merit brief mention.

It is hard to place an estimate upon the value of torpedoes to the Confederate cause. In addition to their actual value as measured by the damage inflicted upon their adversary, the restraining influence exerted by these hidden devices upon the operations of the Federal fleet is hard to overestimate. Often were its blows timidly delivered, or rendered nugatory by the knowledge of their presence, which otherwise would have been driven home. The statement that their use by the South prolonged the war two years seems reasonable, for after the advent of the ironclad fleet, nothing else, it is believed, would have prevented its steaming up to the wharves of Charleston, or into any other Southern port. Booms and piling certainly would not have done so, for the fire of the fleet was sufficient to cover the removal of any ordinary obstructions.

The first recorded use of torpedoes by the Confederates was in July, 1861, against some Federal gunboats lying in the Potomac off Aquia Creek. These consisted of a cylinder of boiler-iron with a powder charge buoyed with an empty oil cask. A fuse led from the cask to the charge. A rope connected each pair of casks, intended to bring the machine up alongside the Yankee craft. The fuses were lit and a number of these were sent down on an ebb tide toward the gunboats. They were discovered, taken in charge by small boats, and the fuses extinguished before harm was done.

In October, 1862, a Torpedo Bureau was established in Richmond, with General Rains in charge, and a Naval Submarine Battery Service organized under Commander Hunter Davidson. An act of the Confederate Congress of that year provided that the inventor of any device by which a vessel of war should be destroyed should receive 50 per cent. of the value of vessel and armament. Torpedo stations were established at Richmond, Wilmington, Charleston, Savannah, and Mobile, and a special corps of operators organized.

The first Federal vessel destroyed was the ironclad gunboat *Cairo*, in the Yazoo River. A demijohn filled with powder, enclosed in a wooden box, and fired by use of a friction-primer, and a long lanyard leading to a pit on shore, were the means employed.

There is on record a list of 30 odd Federal vessels destroyed or seriously disabled by Confederate torpedoes. Of this number 24 were destroyed outright, of which 7 were ironclads and 7 transports. As to locality, 3 were in the Red and Yazoo rivers, 5 in the James, 7 in Charleston Harbor and vicinity, 4 in the St. John's (all transports), 3 in the waters of North Carolina, and 9 in Mobile Bay.

The destruction of the *Tecumseh* before Fort Morgan was accompanied with the most deplorable loss of life, as but 21 out of a crew of 141 escaped, while the blowing up of the *Commodore Jones*, in the James River, was perhaps the most dramatic incident connected with torpedo warfare. In the latter case a tank mine, containing, it is said, 400 lbs. of gunpowder, had been placed below Drury's Bluff, provided with electrical means of discharge. For some months an observer lay concealed in a sand-pit on shore waiting for the expected advance of the Federal gunboats. At last the looked for enemy appeared. The *Commodore Jones*, in advance, had just received orders to proceed to drag for torpedoes when she passed over the fatal spot. The explosion lifted her bodily from the water, her boilers exploded, and more than half her crew were killed, wounded, and drowned.

More than 90 per cent. of those used by the Confederates were mechanical contact mines, and proved dangerous to friend and foe alike, as the loss of several of their own vessels by their means testify. On the James River a number of electrical mines were planted, and in Charleston Harbor, during the general bombardment of April 7, 1863, the *New Ironsides* lay for an hour off Fort Wagner directly over a 2,000-pound electrical boiler-iron mine. The operator tried in vain to discharge it. Treachery was suspected, but it was afterward discovered that an ordnance wagon on passing along the beach had severed the wires.

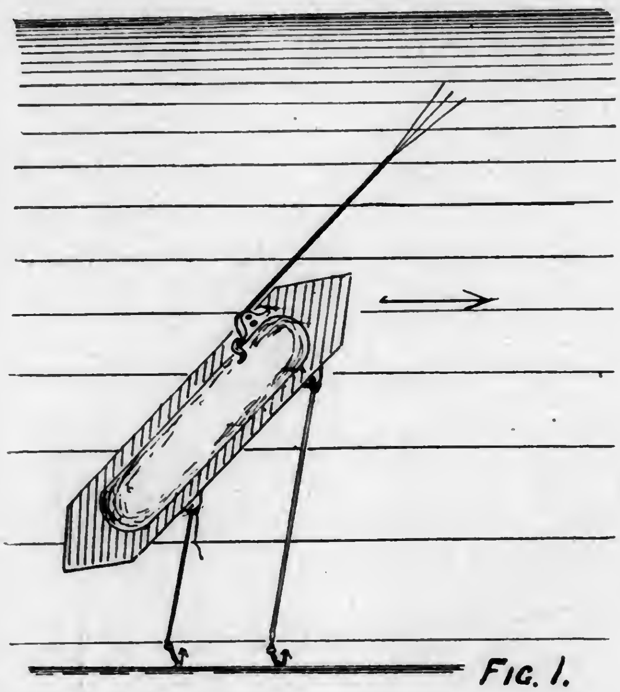


FIG. 1.

The spar torpedo was successfully used in a number of instances. The *Housatonic* was sunk at her anchorage in Charleston Harbor and the *New Ironsides* injured by spar torpedoes. The gallant manner in which Commander Cushing destroyed the Confederate ironclad *Albemarle* in Roanoke River, with a small torpedo launch, had its counterpart in the attempt of Commander Davidson to destroy the flagship *Minnesota*. Davidson, with a small steam torpedo boat, ran down the James from Drury's Bluff, 120 miles, to Hampton Roads, made his way among a crowd of vessels, and exploded a torpedo fairly against the side of the *Minnesota*. The blow was well delivered, but the small charge of 53 lbs. was not sufficient to break in her sides, although considerable damage was done.

In the beginning, torpedo material was, from necessity, very largely improvised. Casks, cans, demijohns, anything that would hold powder and keep out water were used, and some of the arrangements for firing the charges were of the crudest character. Later, better material and better service were secured. The fuses most generally used seem to have been the Jacobi sulphuric-acid fuse, and a very sensitive percussion fuse invented by General Rains, of which mention will be made hereafter.

Besides the common tin-can torpedo, which does not need special mention, there were a number of ingenious construction, some of which proved to be very efficient.

The pronged torpedo, shown in fig. 1, consisted of a hollow wooden or metallic case, anchored near the bottom, inside of which was a 70-pound charge of powder in a bag. A pronged rod projected from the upper side, pointing down stream, so that vessels going with the current could pass over it without harm. A blow upon the prong from the other direction would, however, release a trigger, explode a cap, and fire the charge.

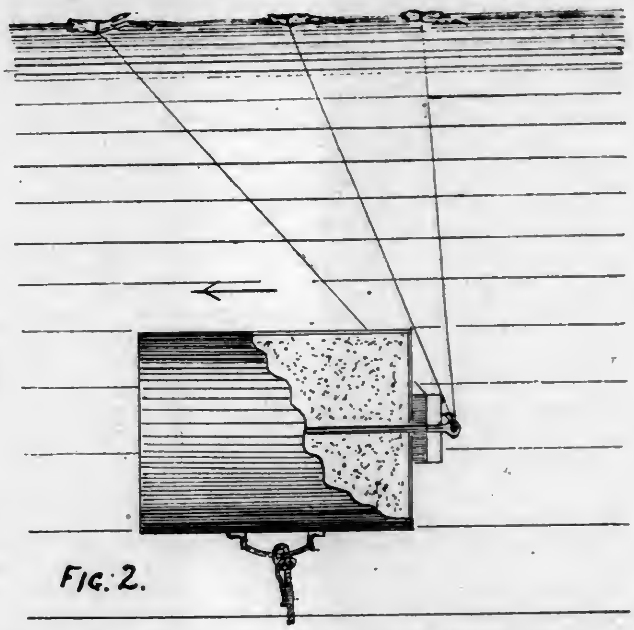


FIG. 2.

The drifting torpedo of various forms was largely used. That shown in fig. 2 was as ingenious as any. It possessed considerable buoyancy and was weighted to a log of proper size to keep it a short distance below the surface. From one end projected a trigger-rod, at the inner end of which was a friction device for igniting the charge; at the other, three trigger lines, attached to small bits of driftwood, reached to the surface. The expectation was that these lines would become entangled in the screws or paddle-wheels of a passing vessel and thus explode the mine. The monitor *Osage* is reported to have been destroyed by a mine of this character.

The coal torpedo shown in fig. 3 had, externally, the appearance of an innocent lump of coal. In reality it was a hollow block of cast-iron, covered with tar and coal dust, and containing, when charged, 10 lbs. of gunpowder. How much injury was inflicted by this kind of explosive is unknown. The transport *Greyhound* is reported to have

FIG. 3.

been destroyed in the James River, in November, 1864, by a coal torpedo, and very possibly some of the unexplained accidents, and unaccountable boiler explosions, of which there were many, may be attributed to the same cause. The most harrowing accident of this kind was the loss, in April, 1865, of the steamer *Sultana*, having on board over 2,100 souls, soldiers, and crew, the former chiefly from hospitals and Southern prisons. Seven miles above Memphis she blew up, and some 1,400 of this number were scalded to death or drowned. The cause of the explosion has never, we believe, been explained.

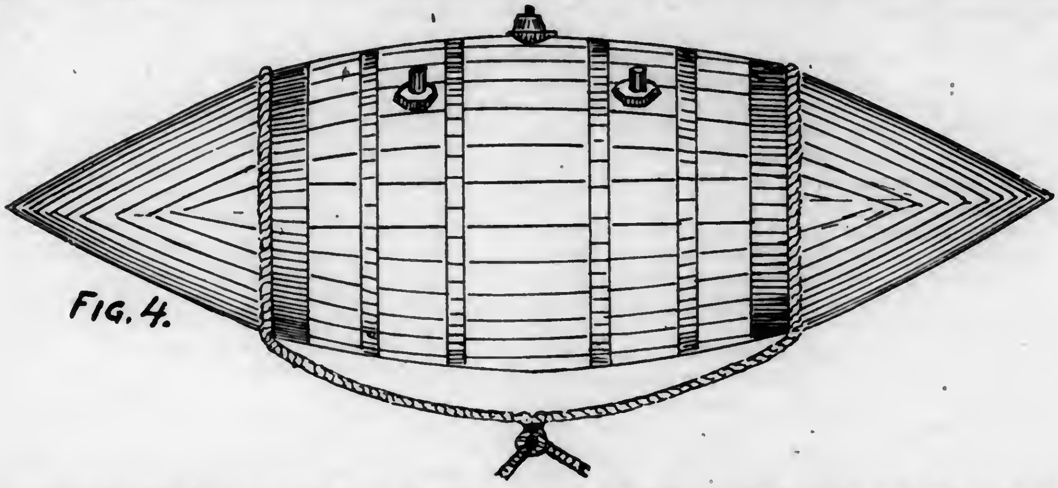


FIG. 4.

Submarine mining and the use of torpedoes in open warfare, are now recognized as perfectly legitimate by all civilized powers. But the use of such a device as a coal torpedo, against whose effects no provision can be made, and which may find its victims among non-combatants, passes beyond the limits of legal warfare and becomes barbarous, and is justly ranked with the poisoning of wells and the spreading of infectious diseases among a hostile people.

One of the most common forms of torpedo used in the South was the keg torpedo (fig. 4). Empty beer casks usually supplied the foundation, to which were added a cone of sheet iron at either end, and a number of projecting percussion fuses along the upper side. In the early days of torpedo construction an order is said to have been issued from Richmond confiscating all the beer kegs in the Confederacy for torpedo purposes.

With such havoc and destruction caused by mines and torpedoes on record at the close of the Civil War, and the practical introduction of high explosives soon after, it is not to be wondered at that even some professional military people should have jumped at the conclusion that the question of harbor defense had been solved, and that in the future it could be left largely to the submarine mine. For some years afterward we find this idea strongly advocated by the press, and even in Congressional debate, and the abolition of sea-coast fortifications was even proposed. Better councils have since prevailed, and mine and torpedo have been assigned their proper rôle in the problem of harbor defense.

(TO BE CONTINUED.)

THE ENGINES OF CRUISER No. 12.

THE accompanying illustrations, which have been prepared from drawings furnished by the Bureau of Steam Engineering, Navy Department, show one of the engines for Cruiser No. 12, the three-screw fast cruiser, for which a contract has recently been let. The ship will have three of these engines, one to each screw.

Fig. 1 is a general elevation of the engine; fig. 2 an end view; fig. 3 a longitudinal section, and fig. 4 a plan of the after end of the ship showing position of the screws; fig. 5 is a view of the ship from the rear, also showing the position of the screws; fig. 6 is a half cross-section showing position of the engine, and fig. 7 also a half cross-section showing position of the boilers in the ship. The engine for the middle screw is placed amidships and aft of the two engines for the outer screws, one of which is shown in fig. 6. Fig. 8 is half an end view and half a cross-section of one of the main boilers, and fig. 9 is a longitudinal section, showing one-half the length of the same boiler. The description given below is from the specifications issued by the Navy Department.

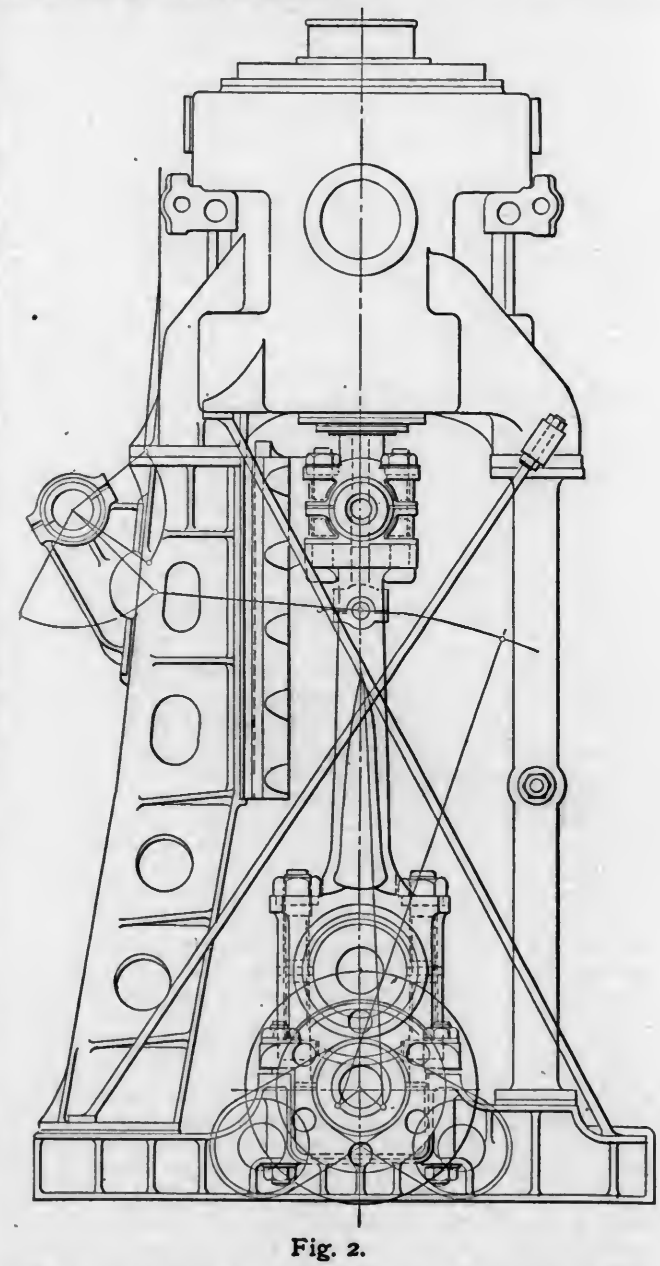


Fig. 2.

The engines are of the vertical, inverted-cylinder, direct-acting, triple-expansion type, each with a high-pressure

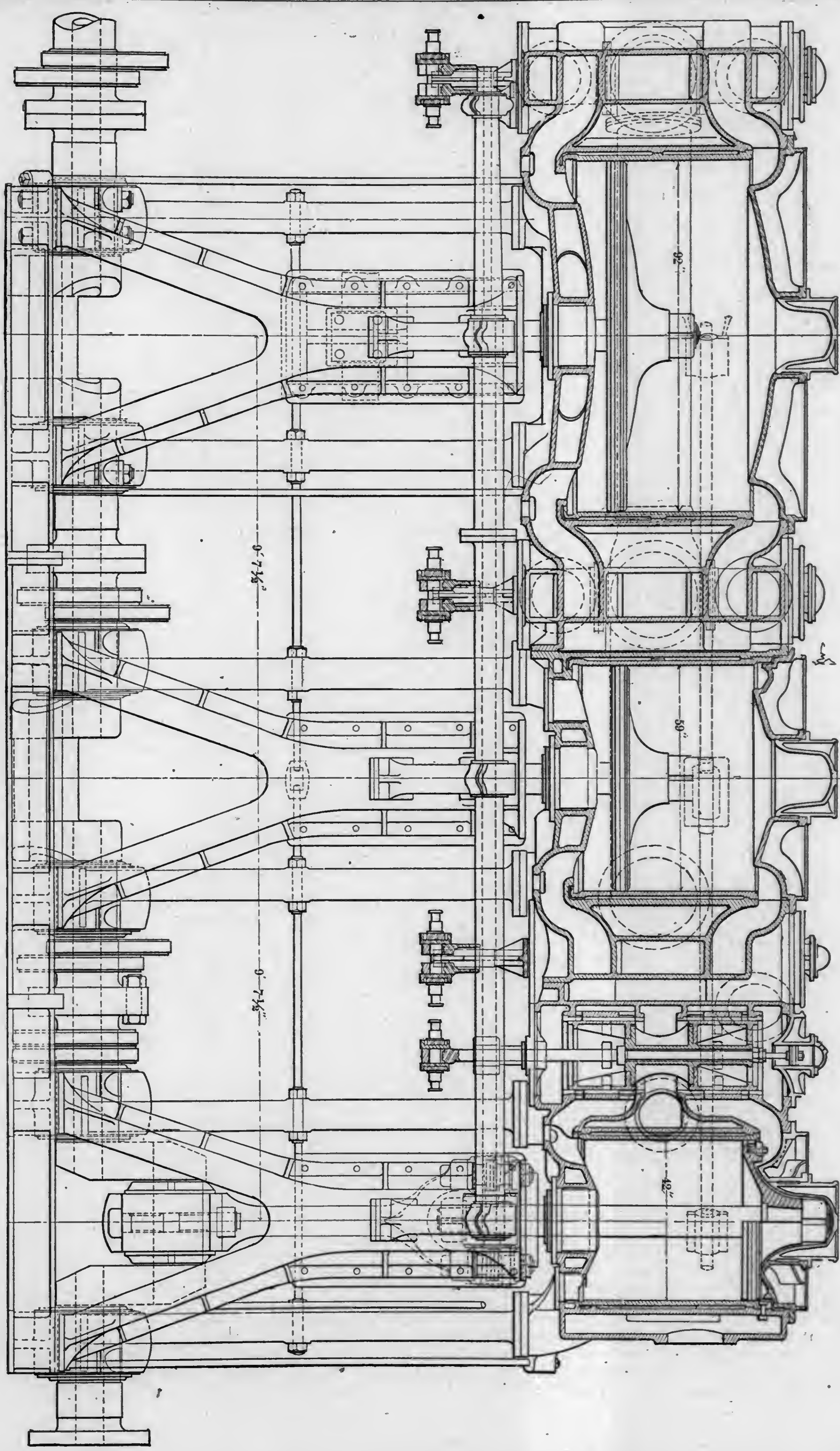
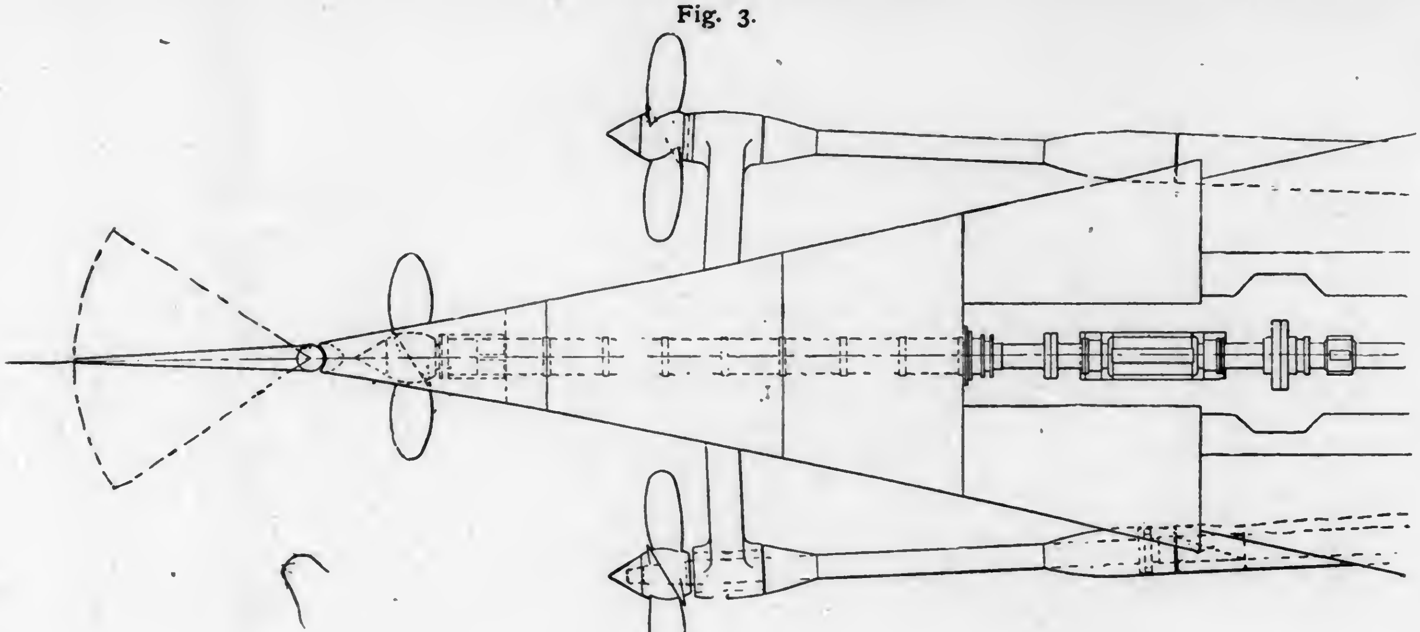


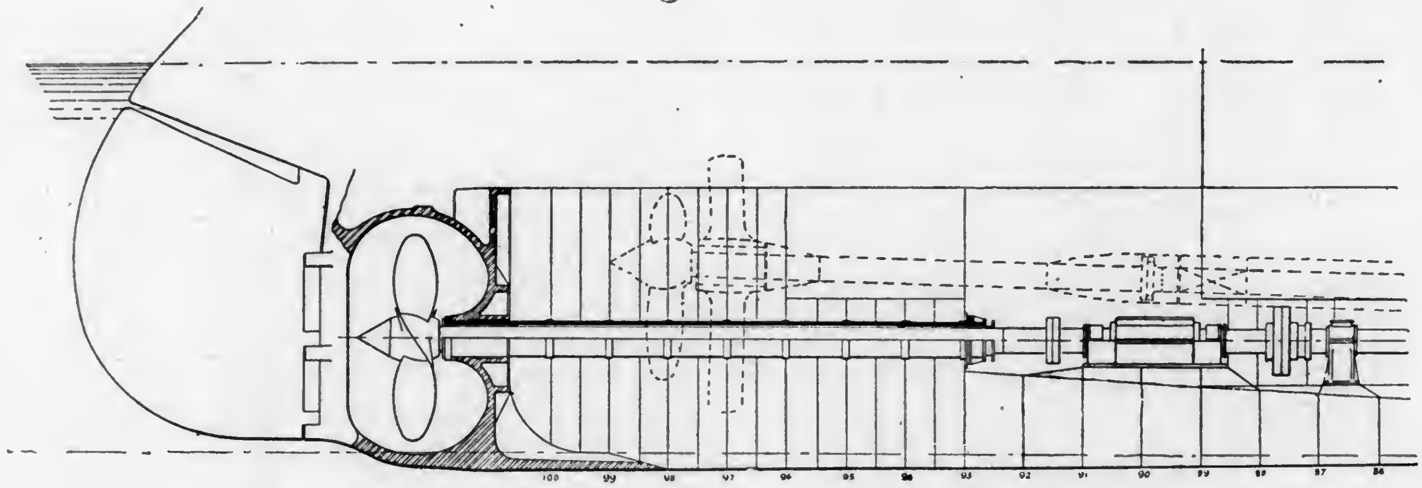
Fig. 1.

TRIPLE-EXPANSION ENGINES FOR CRUISER NO. 12, UNITED STATES NAVY.

DESIGNED BY THE BUREAU OF STEAM ENGINEERING.

Fig. 3.





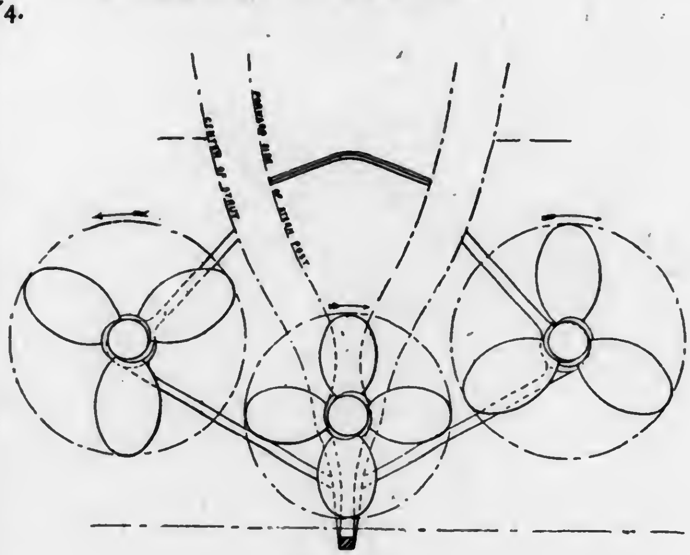
SECTION THROUGH CENTER SHAFT

Fig. 4.

cylinder 42 in., an intermediate-pressure cylinder 59 in., and a low-pressure cylinder 92 in. in diameter, the stroke of all pistons being 42 in. It is estimated that the collective indicated horse-power of the propelling, air-pump, and circulating-pump engines should be about 21,000, when the main engines are making about 129 revolutions per minute.

The high-pressure cylinder of the after engine will be forward and the low-pressure cylinder aft, and the high-pressure cylinder of each forward engine will be aft and the low-pressure cylinder forward. The main valves will be of the piston type, worked by Stephenson link-motions with double-bar links. The valve-gear of the intermediate-pressure and low-pressure cylinders will be interchangeable. There will be one piston-valve for each high-pressure cylinder, two for each intermediate-pressure cylinder, and four for each low-pressure cylinder. Each main piston will have one piston-rod, with a cross head working on a slipper-guide. The framing of the engines will consist of cast-steel inverted Y-frames at the back of each cylinder and cylindrical forged-steel columns at the front. The engine bed-plates will be of cast-steel, supported on wrought-steel keelson-plates built in the vessel. The crank-shafts will be made in three interchangeable and reversible sections. All shafting will be hollow. The shafts, piston-rods, connecting-rods, and working parts generally will be forged of mild, open-hearth steel.

The condensers will be made of composition and sheet-brass, one for each propelling engine. Each main condenser will have a cooling surface of about 9,474 sq. ft.,



LOOKING FORWARD

Fig. 5.

measured on the outside of the tubes. For each propelling engine there will be a double, vertical, single-acting air-pump worked by a vertical, simple engine. The main circulating pumps will be of the centrifugal type, two for each condenser, worked independently. Two of the propellers

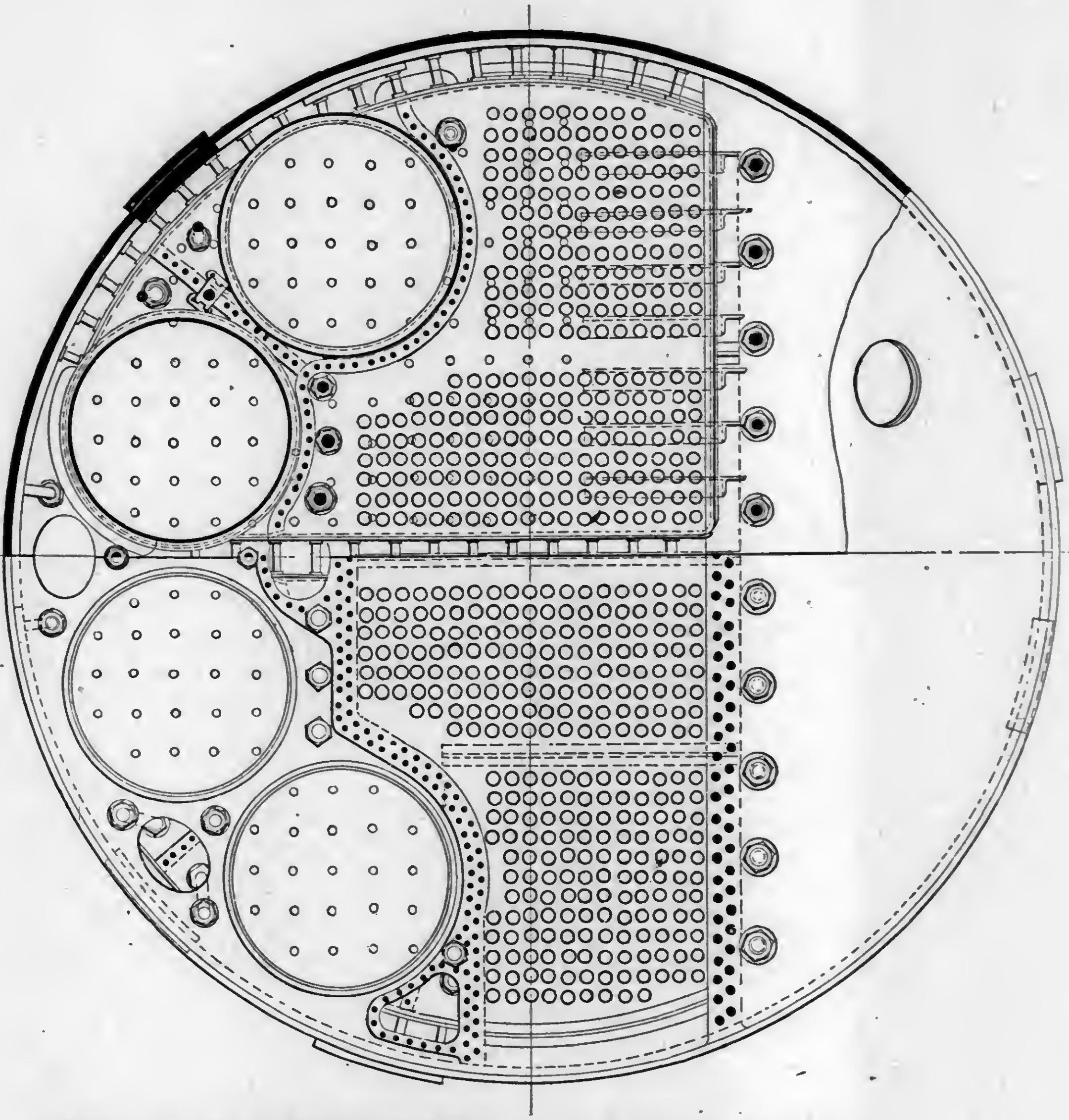


Fig. 8.

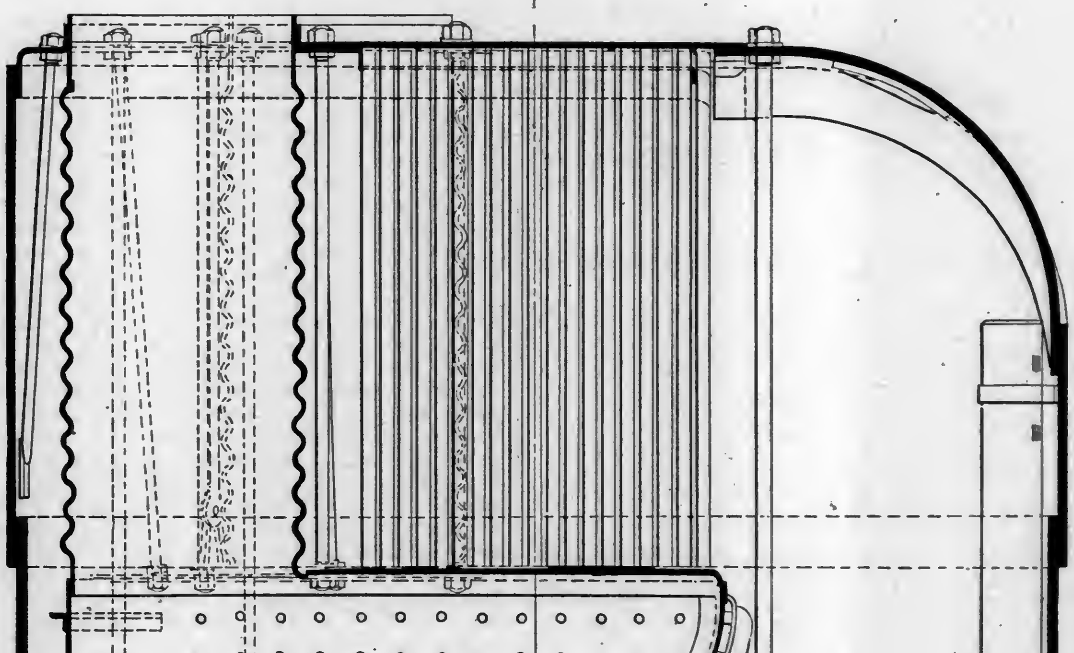


Fig. 9.

MAIN BOILER FOR CRUISER NO. 12, UNITED STATES NAVY.

will be right and one left, to be made of manganese bronze, or approved equivalent metal.

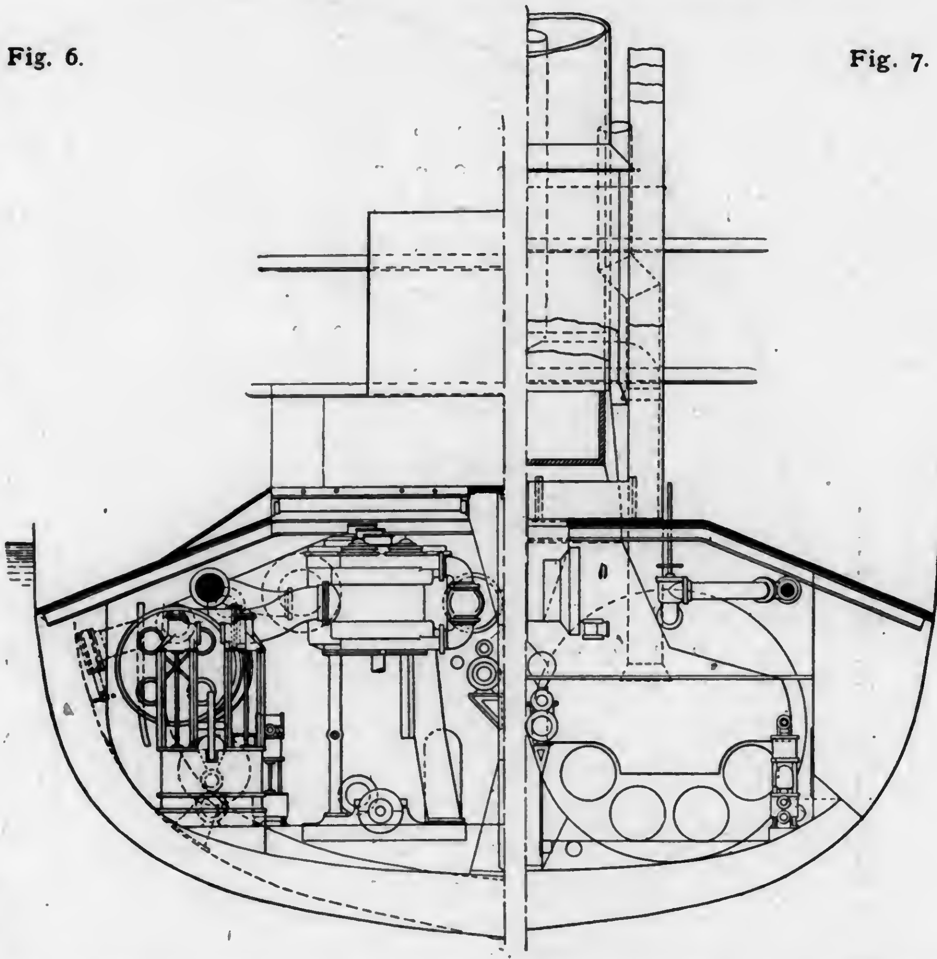
Each engine-room will have an auxiliary condenser made of composition and sheet brass, of sufficient capacity for one third the auxiliary machinery, each condenser being connected with all the auxiliary machinery. Each of these condensers will have a combined air and circulating pump.

There will be six double-ended boilers about 15 ft. 6 in. diameter and 21 ft. 3 in. long, and two about 11 ft. 8 in. diameter and 18 ft. 8½ in. long for the main boilers and two single-ended auxiliary boilers about 10 ft. diameter and 8 ft. 6 in. long. The boilers will be of the horizontal return fire-tube type, all constructed of steel for a working pressure of 160 lbs. per square inch. The main boilers will be placed in four water-tight compartments, and the auxiliary boilers on the protective deck. There will be three athwart-ship fire rooms in each of the main boiler compartments. Each of the double-ended boilers, 15 ft. 6 in. in diameter, will have eight corrugated furnace-flues, 3 ft. 3 in. internal diameter, and each single-ended boiler will have two furnaces 2 ft. 9 in. internal diameter. The total heating surface for the main and auxiliary boilers will be about 43,272 sq. ft., measured on the outer surface of the tubes, and the grate surface 1,285 sq. ft. There will be in each fire-room, in which the check valves are placed, an approved main and an approved auxiliary feed-pump, and in each engine-room an auxiliary feed-pump. There will be three smoke-pipes.

The forced-draft system will consist of one blower for each fire-room, discharging into an air-tight fire-room. Air-tight bulkheads will be fitted so as to reduce the space to be maintained under pressure.

There will be steam reversing-gear, ash-hoists, turning-engines, auxiliary pumps, engine-room ventilating-fans, engine for work-shop machinery, evaporators, and distillers, and such other auxiliary or supplementary machinery, tools, instruments, or apparatus as are described in the detailed specifications or shown in the accompanying drawings.

Fig. 6. Fig. 7.



THE ESSENTIALS OF MECHANICAL DRAWING.

BY M. N. FORNEY.

(*Continued from page* 519.)

CHAPTER VII.—(*Continued.*)

THE STEAM ENGINE.

CONNECTING-ROD.

FIG. 189 represents a connecting-rod, or rather the two *strap-ends* or *stub-ends*, as they are called, by which one end of the rod is attached to the crank-pin, and the other end to the cross-head. In order to save space in the engraving the part of the rod between the strap-ends is supposed to be broken away, and a section only, at the middle, is shown at *A*. As this part of the rod is round and of larger diameter in the middle than it is at *B* and *C*, next to the strap-ends, and is regularly tapered from *B* and *C* to the middle at *A*, all that is required is to show the form of the section which is represented at *A* and give the diameters at *A*, *B*, and *C*, all of which are shown in the engraving.

External views of the one strap-end are shown at the right-hand side of the engraving, whereas at the other side the strap-end is shown in section in both the side view and plan.

In order to resist the wear due to the friction on the crank-pin and cross-head pin, the ends of the rod have brass journal-bearings *D* and *E*, fig. 195, fitted in them. These are made in two parts, which bear against each other on the line *F G*. By this means two objects are attained: first, as brass resists friction better than most other metals, such bearings wear longer than an iron or steel rod would in contact with the crank pin; and second, after the bearings become worn and loose they can be filed away, where they touch each other on the line *F G*, and they can then be drawn together and thus be made tight on the pin. To do this they are attached to the rod by what is called a *strap H*, which is a bar of iron bent into the form of a letter U. This is fastened to the rod by a gib *I* and a tapered *key K*. The gib has heads *J J* above and below the strap to prevent the latter from spreading or separating, and is made tapering or wedgeshaped next to the key. The gib and key are inserted in a slot, shown at *L*, fig. 193, made in the strap and end of the rod. For convenience in manufacture the ends of this slot are made parallel to each other, but the gib and key are made tapered, as already explained, and as shown in the engraving. A little space is left at *M*, fig. 195, between the gib and the rod, and also at *N N*, between the key and the strap. When the key is driven down it bears against the rod at *O*, and the gib bears against the strap at *P* and *P*. Consequently the rod is pushed to the left and the strap is drawn toward the right side which draws the two bearings together. By this means when the bearings become worn and loose they can be made tight by filing them away on their surfaces of contact and then driving down the key. The key is usually held in its place and prevented from working loose by a set-screw, shown in fig. 193, in the side of the rod. This bears against the key and when screwed up tight holds the key securely.

Not much explanation is needed of the method of drawing such a connecting-rod. A center-line should first be drawn for both the side view and plan. A circle whose diameter is equal to that of the crank-pin should then be drawn at one end, and another equal in diameter to the cross-head-pin at the other. The brass bearings can then be laid down around these pins. As shown, one of these has a square outline, and the other where it bears against the strap is octagonal. The bearings at

D and *E* are made thicker than at *F* and *G*, because at *D* and *E* they must resist the thrust and pull of the rod, and consequently they are worn more at these points than they are at *F* and *G*. Besides reducing their thickness at *F* and *G* it facilitates the filing away of the brasses.

The form of strap-end represented in the engraving is not as much used now as it was formerly. For locomotives and other fast-running engines bolts are now very commonly substituted for gibs, as the strap can thus be more securely fastened to the rod than is possible with a gib alone. When bolts are used for fastening the strap to the rod, the key is usually arranged so as to bear directly against one of the brass bearings.

Fig. 193. Fig. 194.

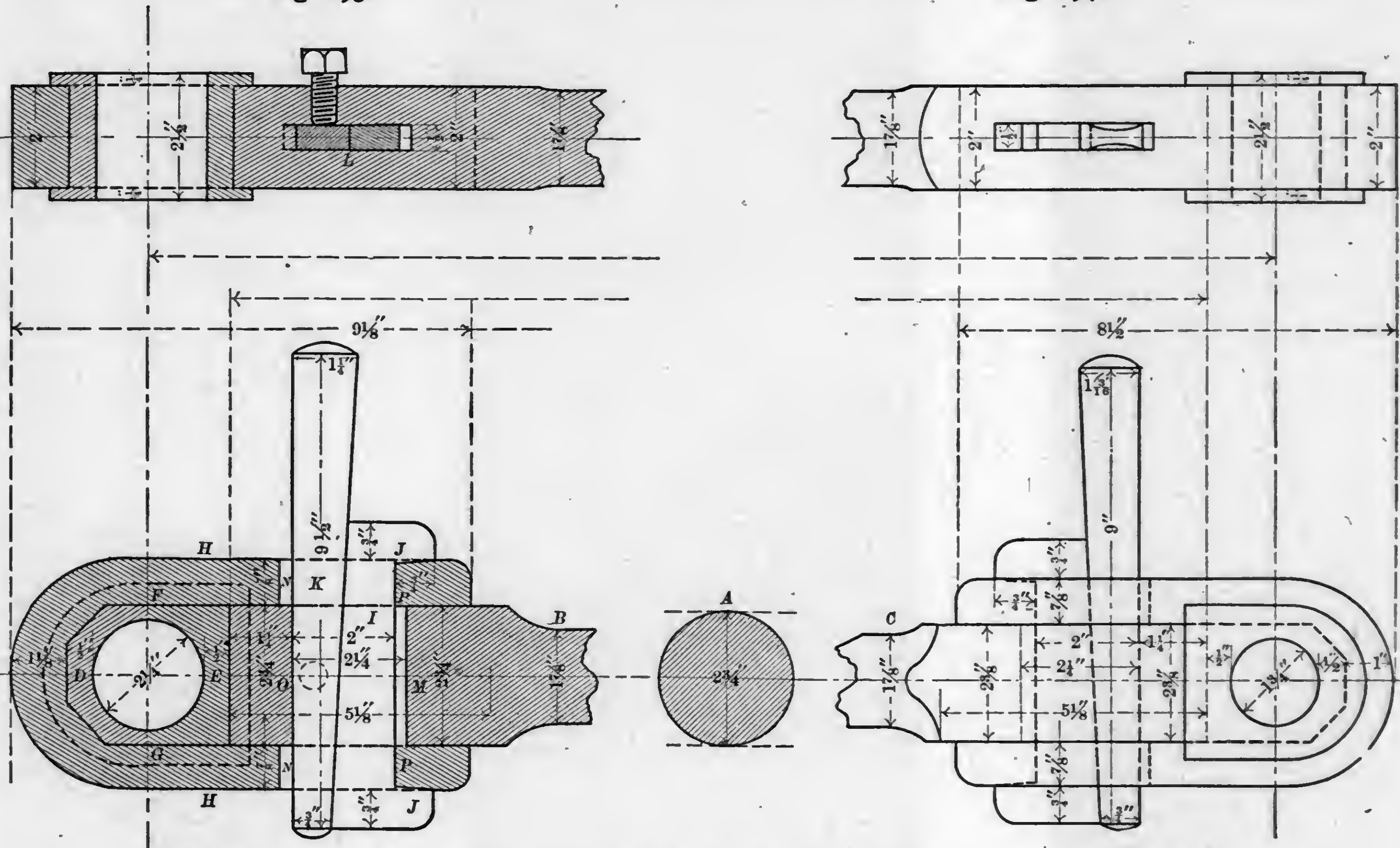


Fig. 195. Fig. 196.

CONNECTING ROD. SCALE, 3 IN. = 1 FT.

MAIN SHAFT.

Fig. 197 represents the main shaft for a stationary engine. No explanation is needed of the method of drawing it, the engraving being sufficiently clear. To save space in the engraving, part of the middle of the shaft is represented as broken away.

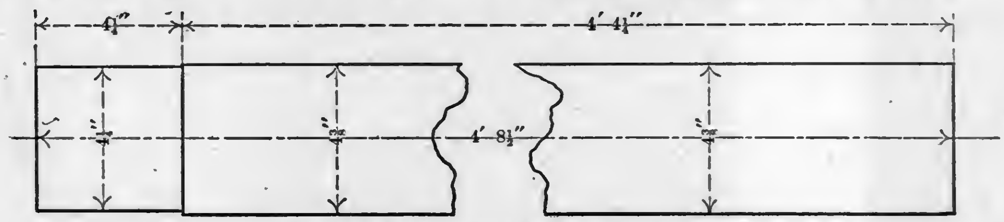


Fig. 197.

MAIN SHAFT. SCALE, 3 IN. = 1 FT.

PEDESTAL.

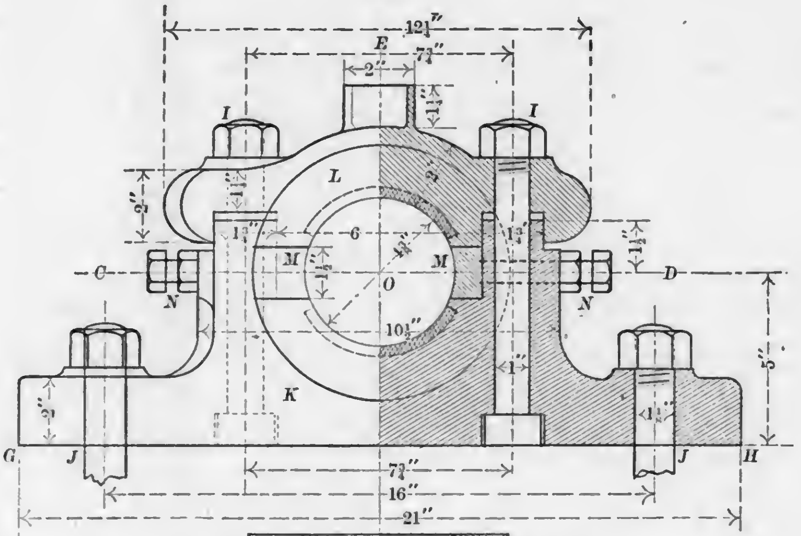
Figs. 198, 199, and 200 represent the pedestal for our stationary engine. The left-hand side of fig. 198 represents a side view, and the right-hand side a section on the center line *A B* of fig. 199. The left-hand side of the latter represents a plan and the right-hand side a sectional plan on the line *O D* of fig. 198. Fig. 196 is an end view.

As shown by the engravings, the pedestal consists of a cast-iron block *K*, with a cap *L* on top which is held by the bolts *I I*. This cap can be removed when the shaft is placed in the pedestal, and when the bearing is worn the cap can be filed away and drawn down by the bolts so as to "take up" the wear at the bottom of the bearing and the under side of the cap. In engines with horizontal cylinders the pressure of the piston is exerted forward and backward, so that the bearing of the pedestal is worn most on its sides. To take up this wear brass gibs *M M* are placed on each side of the shaft. These can be adjusted by set screws *N N*, which push the gibs toward the shaft when they are screwed up. The under side of the cap *L* bears on the gibs *M M*. By filing away either the gibs or the under side of the cap, it can be drawn down by the bolts *I I*. By this means the wear at the top and the bottom of the journal and at the sides can all be taken up, and the shaft can thus be kept sufficiently tight in the pedestal, so that it will not shake or pound, or have any "lost motion," as it is called. The pedestal is bolted to the engine frame by the bolts *J J*.

The student should draw the three views represented by figs. 198, 199, and 200 half size. In doing so he should first draw a horizontal center-line *C D* and a vertical center-line *E F*, both of which will pass through the center *O* of the main shaft. Then from the intersection *O* of these two lines as a center, draw a circle with a diameter equal to that of the journal of the shaft, which in this case in 4⅝ in. Then draw the horizontal base-line *G H* the required distance below the center *O*, which is 5 in. Draw vertical center-lines at equal distances from *O* and 7⅝ and 16 in. apart, which will be the center-lines of the bolts *I I* and *J J*, which may be drawn on these lines after the other parts of the pedestal are laid down.

The width—10½ in.—of the body of the pedestal is laid off from the vertical center-line, and also the width—6 in.—of its jaw or opening which receives the shaft, gibs, and the projec-

Fig. 198.



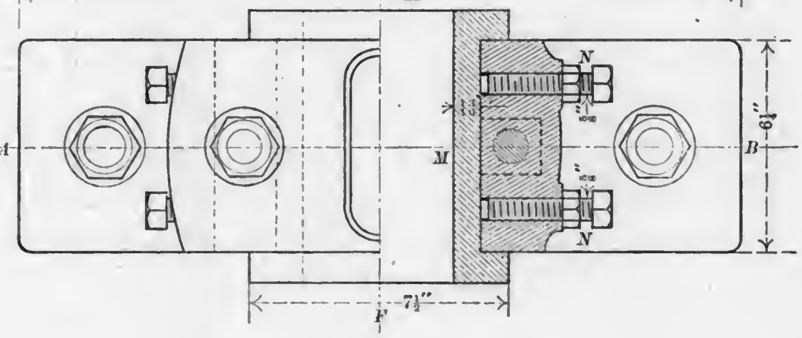
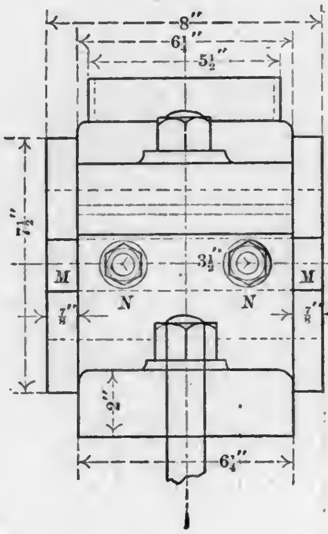


Fig. 199.

Fig. 200.



PEDESTAL. SCALE, 2 IN. = 1 FT.

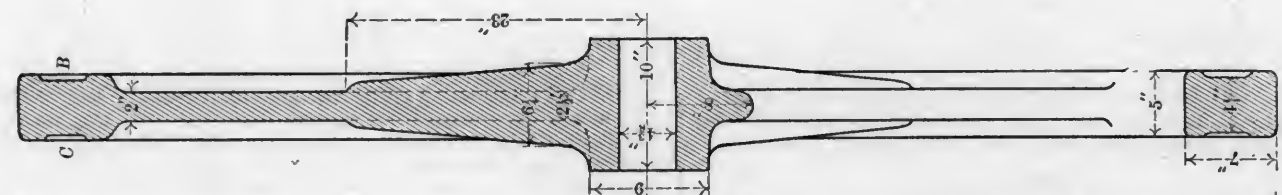


Fig. 202.

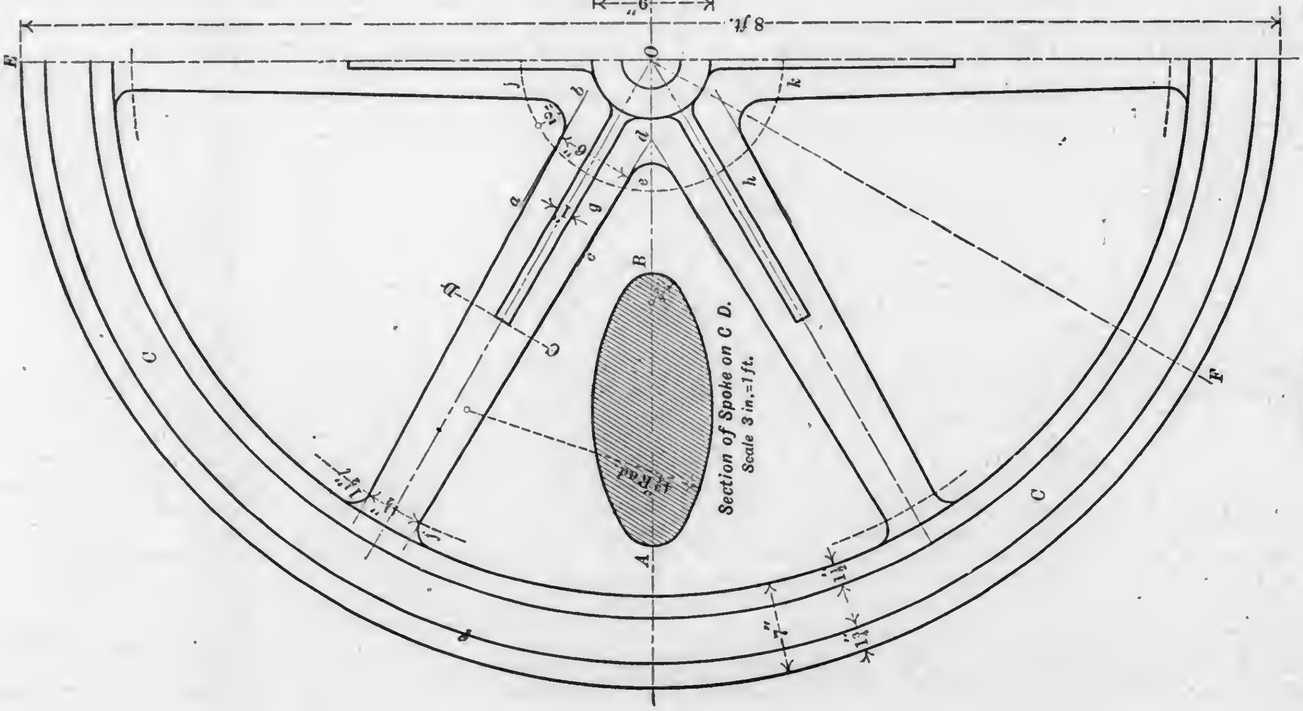


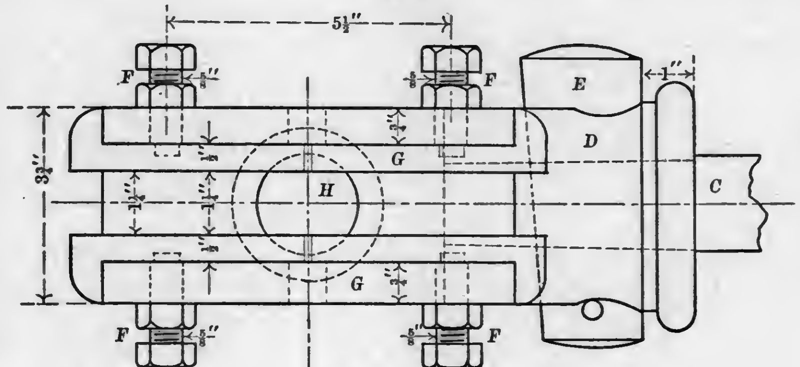
Fig. 201.

FLY WHEEL. SCALE, ¾ IN. = 1 FT.

tion on the lower side of the cap. The thickness of the cap above the shaft is readily laid down and its outline is drawn from the center *O*. The set-screws *N N* are drawn on the horizontal center-line *C D*, and in fig. 199 are laid off the proper distance apart, or, as shown in fig. 200, 3½ in. measured from center to center. It will be noticed that each of these screws has a nut on it which bears against the pedestal. This is called a *lock-nut*, and its object is to clamp the screw and prevent it from unscrewing and thus allow the gibs to get loose. The inside of the cap and the bearing on the pedestal has a lining of Babbitt or other metal, which will resist wear better than cast-iron does. This lining is indicated in the section by cross-lines.

It will be seen that all of these views are drawn from one or more center-lines. These should be laid down first, and the student should work from them. The same method should be followed in drawing many of the subordinate parts, as the bolts and set-screws.

Fig. 203.



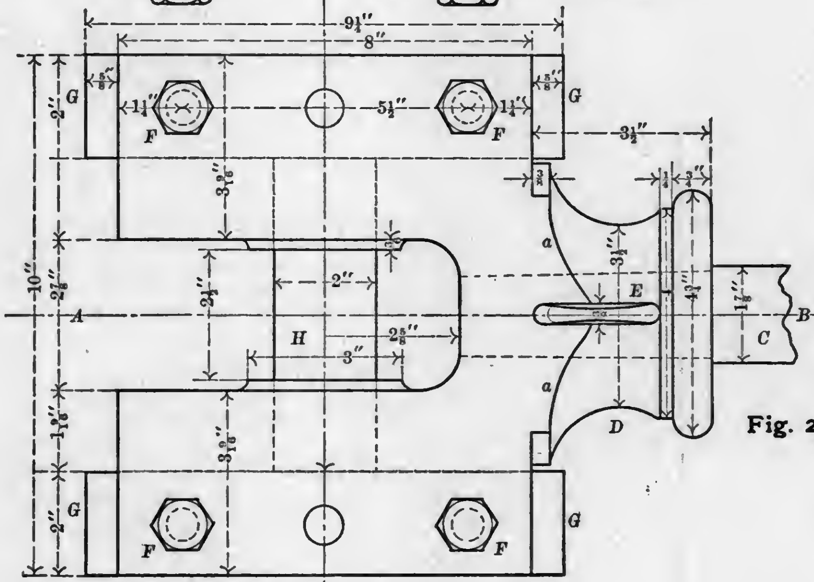


Fig. 204.

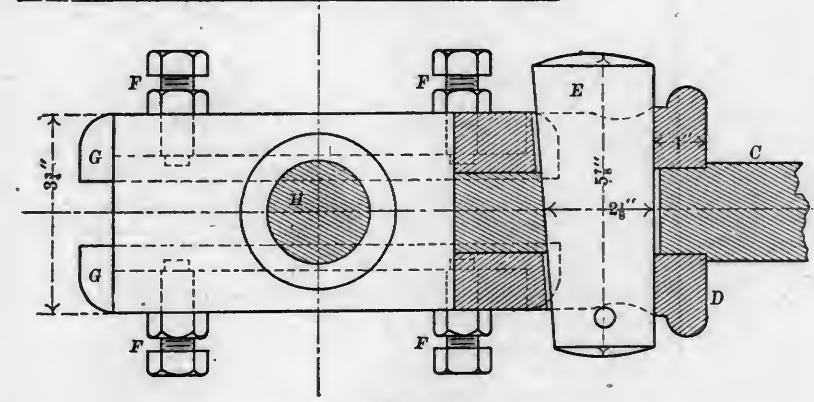
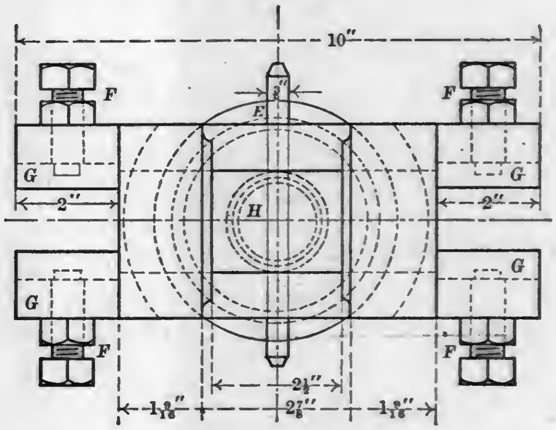


Fig. 205.

CROSS-HEAD. SCALE, 3 IN. = 1 FT.

Fig. 206.



FLY-WHEEL.

Fig. 201 represents a side view of one half of a fly-wheel. One half only of the wheel is shown, because the other half is exactly like it, and also to save space in the engraving and time in making the drawing. The student can draw the whole of the wheel if he is ambitious to produce a handsome pictorial effect. The drawing should be made to a scale of 1½ or 2 in. = 1 ft. Fig. 202 is a section on the line *E O F* of fig. 201. Fig. 202 is drawn on this irregular line in order to show a section of one of the spokes, and also the form of the hub and rim between the spokes. A section of one of the spokes on the line *C D* is shown at *A B*. This is drawn on a larger scale than the wheel itself.

The method of drawing a fly-wheel is very similar to that employed to represent a pulley described in the last chapter. The rim should be drawn first and divided into as many equal parts as there are spokes—in this case six. Center-lines should then be drawn through the points of division and the center *O* of the wheel. Next draw the hub or nave, and then draw lines *a b* and *c d* parallel to the center-line of the spoke, and at equal distances from it, and let their distance apart be 6 in., or equal to the width of the spoke next to the hub. Then unite these lines by a curve, as shown at *e*. Repeat this at the ends of the spokes next to the rim, making the distance between the lines at this point equal to 4½ in., or the width of the spokes at that point. Draw curves as at *f*, uniting the parallel lines with the inside of the rim, and then unite these curves as *f* and *e* by a line *f e*, which will be the outline of the arm or spoke. Another method, which saves some work, is to lay off one of the curves at *f* and at *e* and then draw a circle, as *j e k*, or arcs of circles, as *l f*, which will pass through the centers of the curves *e* and *f*. Then lay off the width of the arms next to the hub, on the circle *j e k*, and that next to the rim on the arcs, as *l f*, and draw the outlines of the arms through the points thus laid off. The curves *f e* can then be added after the outlines of the arms have been drawn.

At *g* and *h* are ribs cast on the spokes to strengthen them next to the hub. The form of these ribs is shown in the upper part of the section, fig. 202.

The recesses or channels *G* and *H* are cast in the sides of the rim of the wheel to diminish the amount of surface to be turned off, and also to improve the appearance of the wheel. The spokes, it will be seen, are elliptical in shape, but are sometimes made rectangular or in the shape of a cross in section.

CROSS-HEAD.

Figs. 203 to 206 represent the *cross-head* of the engine whose parts are being illustrated in this chapter. As was recommended in other examples, the cross-head should be drawn either half or full size.

A *cross-head* is a sliding block attached to the end of the piston-rod to cause the latter to move in a straight line. Fig. 203 is a side view, fig. 204 a plan, fig. 205 a longitudinal section on the line *A B* of fig. 204, and fig. 206 is an end view looking at the left-hand end of fig. 203.

The piston-rod *C* is made to fit accurately in a conical hole in the boss *D*, and is held there by a tapered key *E*. A pair of brass gibs, *G G*, are attached to each side of the cross-head.

These slide on guides which are not shown in the engravings, and thus cause the cross-head to move in a straight line, which coincides with the center-line of the cylinder. The gibs are pressed down on the guides by set-screws *F F*, so that when the gibs wear they can be adjusted and kept tight on the guides. Each set-screw has a lock-nut which bears on the cross-head. The object of this is to hold the set-screw securely and prevent it from working loose. One end of the connecting-rod is attached to the pin *H*, and the other end to the crank.

The student will not encounter any special difficulties in drawing the cross-head, which are not explained by the engravings. Horizontal and vertical center-lines should be drawn for each view and the different parts laid off from these lines. The curved line *a a* on the plan, fig. 204, represents the intersection of the flat surface of the top of the cross-head with the round surface of the boss *D*. The method of laying off such intersections will be explained in another chapter. For the present the student may simply copy the curved line from the engraving.

(TO BE CONTINUED.)

Manufactures.

Electric Notes.

THE electric headlight invented by Mr. G. C. Pyle, of Indianapolis, Ind., and manufactured by the National Electric Headlight Company, has been tried on several roads. The arrangement adopted is the placing of a small dynamo in front of the smoke-stack and directly behind the headlight. This dynamo is run by a small four-cylinder engine enclosed in a case and receiving steam from the locomotive boiler, the whole arrangement being very compact and taking up but little room. An arc lamp is used which is substituted for the usual lamp in the headlight, and the results are said to be very good, light being thrown upon the track for a long distance ahead.

THE latest application of electric welding is in the manufacture of projectiles. Steel shells welded by electricity present, it is said, many points of superiority over those made in the ordinary manner.

Marine Engineering.

AT the yard of Neafie & Levy, in Philadelphia, a new ferry-boat for the New York, Lake Erie & Western Railroad has recently been launched. This boat differs from those already owned by the Company in having two screws, one at each end, like the ferry-boat *Bergen*, which has already been described in our columns. Like that boat, the shaft runs the entire length of the boat. The new ferry-boat is 215 ft. long over all ; 188 ft. 3 in. long between stern posts ; 45 ft. beam, and 16 ft. depth of hold. The engines are of the compound type, with cylinders 26 in. and 50 in. in diameter by 30 in. stroke.

THE Columbian Iron Works, Baltimore, have recently completed a steel tank steamer for the Standard Oil Company, which is the second steamer of this class built in the United States. The vessel has a capacity of 500,000 gals. of oil in her tanks, and is provided with Blake pumps which can empty these tanks in seven hours. She has a triple-expansion engine with cylinders 19 in., 30 in. and 50 in. in diameter by 36 in. stroke, operating a Hirsch propeller 11 ft. in diameter and 14 ft. pitch. Steam is supplied by two boilers of the Scotch type 12 ft. 9½ in. in diameter and 8 ft. 8 in. long. The engines have worked up to 1,300 H.P. The ship is provided with electric lights throughout.

Locomotives.

THE Kingston Locomotive Works, Kingston, Ont., are building five 10-wheel locomotives for the Canadian Pacific ; 10 heavy mogul engines for the Grand Trunk, and four heavy tank locomotives for the Chignecto Ship Railroad in Nova Scotia.

THE Baldwin Locomotive Works, of Philadelphia, have a contract for 50 locomotives for the Great Northern Railroad, to be used on the Pacific extension of the line.

THE Richmond Locomotive Works, Richmond, Va., have recently received a contract for six passenger, three freight, and one shifting engine for the Louisville & Southern Road.

THE Western Locomotive Company has been incorporated with a capital of $2,500,000 for the purpose of building shops in Seattle, Wash., for the manufacture of locomotives. It is stated that the shops will be built at once.

THE shops of H. K. Porter & Company, in Pittsburgh, have just completed a Forney locomotive for the Milwaukee & White Fish Bay Railroad, a suburban line. The engine has 12 × 18 in. cylinders, and four drivers and weighs 23 tons ready for service. It is provided with the noiseless exhaust and Eames brake.

THE Baldwin Locomotive Works, Philadelphia, have an order for 12 ten-wheel passenger engines for the Government of New South Wales. These engines are required to haul passenger trains weighing 144 gross tons at a speed of 22 miles per hour up a grade of 176 ft. to the mile, or trains weighing 176 tons at the same speed up grades of 130 ft. to the mile, on which there are curves of 528 ft. radius. The general plan of these engines is the Baldwin, but in some respects the specifications conform to English practice, and they will have copper fire-boxes and stay-bolts and brass tubes.

AT the shops of H. K. Porter & Company, Pittsburgh, a very small locomotive was recently completed for the Otis Steel Company. It is 23½ in. gauge, has cylinders 5 in. in diameter and 10 in. stroke, and four driving-wheels 22 in. diameter. The entire weight of the engine in working order is about three tons.

THE Dickson Manufacturing Company, Scranton, Pa., is building 15 mogul locomotives for the Delaware & Hudson Canal Company.

Bridges.

THE San Francisco Bridge Company has been awarded contracts for the building of three bridges on the Great Northern Railroad in Washington. The first of these, over the Snohomish River, will be 1,700 ft. long ; the second, over the Stillaguamish, 400 ft., and the third, over the Skagit, 600 ft. in length.

THE Shiffler Bridge Company has the contract for a new bridge over the Mississippi at Minneapolis. It will be about 1,700 ft. long in all, consisting of four spans over the river and an iron viaduct approach.

THE Pencoyd Iron Works, Philadelphia, Pa., have received the contract for building the east approach to the Walnut Street bridge over the Schuylkill River in that city.

Manufacturing Notes.

THE mill of the Kellogg Tube Works, at Findlay, O., has been enlarged and improved, and machinery put in for rolling seamless tubes from hollow ingots by the process patented by William Heckert, the General Superintendent of the works. This process has been fully tested with very successful results.

THE Crown Smelting Company, Chester, Pa., has recently completed its new foundry buildings, which have been fitted up especially to make castings in bronze or brass for heavy machinery and marine work. This Company also manufactures phosphor-bronze metal, and is doing considerable work for railroad companies.

THE Tidewater Steel Company, Chester, Pa., is manufacturing the Lewis & Fowler girder rail for street railroads, which is being adopted by a number of lines.

THE Lake Erie Engineering Works are building new shops in Buffalo, N. Y. These include a machine-shop 250 × 112 ft. and a foundry 230 × 112 ft. Both the machine-shop and foundry will be provided with 30-ton traveling cranes, by which work can be moved to any part of the shop.

Cars.

THE St. Charles Car Company, St. Charles, Mo., has recently completed two very handsome private cars, one for the Monterey & Mexican Gulf Railroad, and the other for the Rio Grande Western.

THE Scarritt Furniture Company, St. Louis, has the contract for Forney car-seats for a number of new cars which the New York, Lake Erie & Western Company is building for suburban travel.

THE shops of the United States Rolling Stock Company at Anniston, Ala., have recently turned out 100 box cars for the Cincinnati, New Orleans & Texas Pacific ; 200 fruit cars for the Georgia Southern & Florida ; 60 flat and 40 stock cars for the New Orleans & Northeastern.

IN accordance with the advice of a committee of creditors, a receiver has been appointed for the Harrisburg Car Manufacturing Company. Under his charge it is believed that the Company's affairs can, in time, be satisfactorily adjusted.

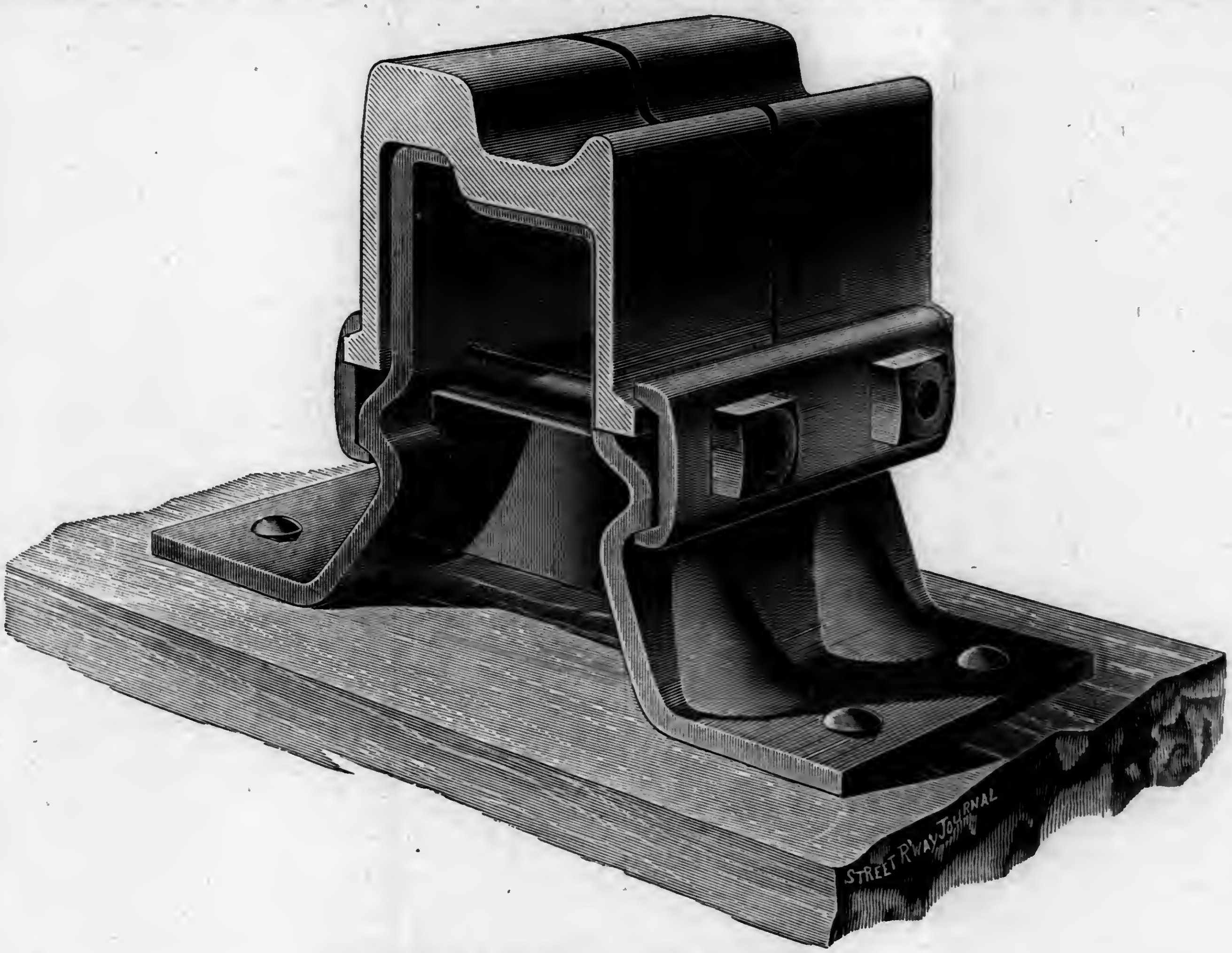
A New Street Rail.

THE accompanying illustration shows the Lewis & Fowler girder rail for street railroads, the cut being a perspective view of a joint, showing a cross-section of the rail and an end view of one of the chairs or supports. The general plan and construction, which is that of a box or girder rail carried on chairs spiked or screwed to the ties, will be readily understood from the engraving.

The advantages claimed for this rail are proper distribution of metal to secure strength, and the fact that the joints and fastenings are so arranged that they will not loosen the first time there is a change in the atmosphere, provision being made by the spring of the rail flanges to take up all wear that may occur by contraction and expansion. The joints can be placed on chairs, or suspended between the ties, as preferred. The rail has no flanges or projections to interfere with the street pavement, and no holes are required in the web of the rail to weaken it. The head can be rolled of any shape desired, as well as of the form here shown. It is calculated that with six single chairs and one double (or joint) chair to a 30-ft. rail, the heaviest electric car can be carried with only very slight deflection.

The rails are rolled of steel, with the flanges projecting slightly outward, as well as downward, and when the fastenings are applied the flanges (or webs) are sprung into a vertical position. The bead at the bottom edge of the flange has an inclined top. The bead (or lip) on the clamp, which engages with the lip on the rail, draws the chair and rail firmly together, as the points of contact between rail and chair wear ; the flanges of the rail being sprung in, naturally have a tendency to spring back to their normal positions, forcing the bead of the rail under the bead of the clamp, thereby holding the rail and chair firmly together.

These rails are being introduced by the Lewis & Fowler Girder Rail Company, of Brooklyn, N. Y. They are manufactured in Chester, Pa., at the mills of the Tidewater Steel Company.



THE LEWIS & FOWLER GIRDER STREET RAIL.

OBITUARY.

ABRAM S. HULL, who died recently at his home in Chambersburg, Pa., was Master Mechanic of the Cumberland Valley Railroad for the long period of 34 years. He was born in 1826, and learned the machinist's trade in the Cumberland Valley shops, of which his father was Foreman. After seven years spent in various towns in the neighborhood, he again found employment in the railroad shops, and three years after this, in 1855, he was made Master Mechanic. A year ago he resigned, and was appointed to another position on the road. Mr. Hull was greatly respected and liked by all who knew him. He had much ability as a mechanic, and the faculty of imparting his knowledge to his subordinates.

SAMUEL ARCHBOLD, who died at his residence in Westover, Md., October 21, aged 74 years, was for many years a prominent naval architect. He entered the Navy in 1843 as assistant engineer and was gradually promoted, becoming Chief Engineer in 1859, after 16 years of continuous service, much of it at sea. He took part in the Mexican War and also in the Perry Expedition to Japan. In 1859 he resigned from the Navy and joined with Thomas Reaney in forming the firm of Reaney & Archbold, which established at Chester, Pa., what is now one of the largest ship-yards in the country. During the War a

great deal of work was done there for the Government. His business was carried on until 1871, when from various causes the firm failed, and the property afterward passed into the hands of the late John Roach. Mr. Archbold was then appointed Consulting Engineer for the Philadelphia & Reading Railroad Company, and under his supervision the Company's fleet of steel colliers was built, and also the repair shops at Port Richmond, which are now disused. In 1880 Mr. Archbold resigned and retired from active business, and since that time had lived in Maryland. His services were frequently called upon as Consulting Engineer, and he was a member of the Naval Advisory Board under Secretary Whitney, where his services were much appreciated.

PERSONALS.

CHIEF ENGINEER DAVID SMITH, U.S.N., has been detailed for duty as a member of the Steel Inspection Board.

ALLEN S. COOKE has resigned his position as General Master Mechanic of the Chicago & Eastern Illinois Railroads.

FRANK E. MERRILL has been appointed Superintendent of the Chicago & Erie Railroad. He was recently on the St. Louis & San Francisco.

JAMES COLLINSON is now Master Mechanic of the Chicago Division of the Atchison, Topeka & Santa Fé Railroad, with office at Fort Madison, Ia.

E. H. GOODMAN, General Manager of the Union Switch & Signal Company, has been chosen Vice-President in place of CHARLES H. JACKSON, who has resigned to take charge of the United Electric Light and Power Company, of New York.

SAMUEL M. FELTON, JR., has been chosen President of the East Tennessee, Virginia & Georgia Railroad Company. He has been for several years Vice-President of the New York, Lake Erie & Western Company, and has held other important positions.

JOHN MULLIGAN has been chosen President of the Connecticut River Railroad Company in place of N. A. Leonard, deceased. Mr. Mulligan has been connected with the road for 38 years, having been 16 years Master Mechanic and 22 years Superintendent.

ASSISTANT NAVAL CONSTRUCTOR LEWIS NIXON, U.S.N., has resigned and has accepted the position of Naval Architect of the William Cramp & Sons Ship and Engine Building Company in Philadelphia. Mr. Nixon has served 11 years in the Navy, and has done much good work as a designer.

ENSIGNS ROBERT STOCKER and ELLIOTT SNOW, ASSISTANT ENGINEER FRANK HIBBS and NAVAL CADET RICHMOND P. HOBSON, have been ordered by the Secretary of the Navy to the Ecole Maritime, at Paris, for a course of instruction in shipbuilding and Naval construction. NAVAL CADETS GEORGE H. ROCK and T. F. RUHM have been ordered to Glasgow, Scotland, for the same purpose.

PROCEEDINGS OF SOCIETIES.

American Institute of Architects.—The 24th annual convention was held in Washington, beginning October 22, and was a very successful meeting.

The following officers were chosen for the ensuing year: President, R. M. Hunt, New York. Vice-Presidents, W. W. Carlin, Buffalo, N. Y.; J. W. McLaughlin, Cincinnati. Secretary, J. W. Root, Chicago. Treasurer, S. A. Treat, Chicago. Directors: L. T. Scofield, Cleveland, O.; W. M. Poindexter, Washington; G. M. Ferry, Milwaukee, Wis.; C. J. Clark, Louisville, Ky.; M. J. Dinmock, Richmond, Va.; Alfred Stone, Providence, R. I.; E. F. Fassett, Kansas City, Mo.; George C. Mason, Jr., Philadelphia.

Roadmasters' Association of America.—The Executive Committee makes the following announcement of the subjects on which reports are to be presented at the next yearly convention. The names of the committees are given with each subject:

1. *Frogs:* James Sloan, James Ryan, Timothy Hickey, P. Nolan, C. E. Jones, W H. Courtney, and J. A. Kerwin.
2. *New Joints:* B. Mertaugh, George E. Daggett, C. E. Marvin, J. A. Prentice, M. J. McInarna, J. H. Preston, and Alexander McGregor.
3. *Interlocking Devices and Position of Guard-rail at Derailing Switches:* R. Black, W. H. Stearns, J. Wynn, C. N. Comerford, J. H. K. Burgwyn, J. W. Offutt, and G. M. Brown.
4. *Track Jacks:* J. M. Meade, J. D. Mandeville, F. C. Clark, F. X. Gatlarneau, M. Shea, N. A. Freeland, and D. P. Beatty.
5. *Best General Methods of Doing Track Work upon the Different Kinds of Ballast:* O. F. Jordan, C. H. Cornell, J. E. Dorsey, J. C. Ryan, S. H. Brown, H. D. Hanover, and J. B. Gilchrist.
6. *What is Considered to be the Best Proportion of Chemicals Found in the Steel Used in the Manufacture of Rails; also Weight and Section of Rails Necessary to Secure the Best Results:* R. Caffrey, William Riley, J. E. Cox, P. H. Loftus, William Wright, C. Buhrer, and James Schofield.
7. *Which Mode of Laying Rails will Give the Better Results, Broken or Even Joints?* John Sloan, James Bolan, P. K. Roach, A. J. Diddle, J. R. Patch, D. H. Lovell, and J. H. Linsley.

The convention will be held in Minneapolis, Minn., on the second Tuesday in September, 1891.

American Society of Civil Engineers.—At the regular meeting, October 5, it was stated that the Nominating Committee had presented the following names for officers for the ensuing year: President, Octave Chanute; Vice-Presidents, John Bogart and Charles Hermany; Secretary, John C. Trautwine, Jr.; Treasurer, George S. Greene, Jr.; Directors, Theodore Cooper, Rudolph Hering, Edward P. North, Clemens Herschel, and S. Whinnery.

The paper of the evening was on Self-Purification of Water in flowing Streams, by Dr. Charles G. Currier, and was illustrated by microscopic exhibits. It was discussed by Messrs. Brush, Harris, Washburn, and others. The discussion was not concluded, but was continued to a subsequent meeting.

The tellers announced the following elections: *Members:* Francis R. Fava, Jr., Washington; Alexander E. Kastl, Tampico, Mexico; James Ritchie, Pittsburgh, Pa.; John N. Ostrom, New York.

Associate: Henry S. Jacoby, Ithaca, N. Y.

Juniors: Henry L. Davis, New Haven, Conn.; Walter D. Dusenberry, New York; George H. Paine, Swissvale, Pa.; Lee Treadwell, Sioux City, Ia.; Arthur L. Shreve, Baltimore, Md.

American Society of Mechanical Engineers.—The fall meeting of this Society was held in Richmond, Va., beginning November 11. The opening session included addresses of welcome from the city authorities and the annual address of the President of the Society. In the evening a public reception was given to the members by the Governor of the State.

On the second day a business session was held in the morning, at which papers were presented and the annual reports of the officers of the Society were read and passed upon. In the afternoon the members joined in a steamboat excursion down the James River, at which a number of points of interest were visited. In the evening a business session was held for reading of papers and topical discussions.

On November 13, a session for reading papers and discussions was held in the morning. In the afternoon the members visited points of interest in the neighborhood of Richmond, and in the evening attended a reception given in their honor by the citizens of Richmond.

Friday, November 14, was devoted to an excursion by special train and boat to Newport News and Norfolk, where the members visited the new shipyards at Newport News, docks at that place, points of interest at Old Point Comfort and vicinity, the Navy Yard, and other establishments at Norfolk. From that point most of the members returned directly home.

Master Car-Builders' Association.—The Committee on Joint Inspection at Interchange Points has issued a circular, requesting information from members as to the present practice in relation to joint inspectors, the results obtained and the methods adopted to enforce the rules of interchange and to secure uniformity in inspection. Answers to this circular are to be sent to the Chairman of the Committee, Mr. A. M. Waitt, of the Lake Shore & Michigan Southern, at Cleveland, O.

New York Railroad Club.—An adjourned meeting of this Club was held at the new rooms in the Gilsey House, New York, November 20, at which a new constitution and by-laws were presented and adopted, and the club organized for the ensuing season. The following officers were chosen for the en-

suing year: President, Ross Kells; Vice-Presidents, R. C. Blackall, W. L. Hoffecker and Frank S. Gannon; Secretary, H. G. Prout; Treasurer, C. A. Smith; Executive Committee, John S. Lentz, Wm. Buchanan, W. H. Lewis, H. S. Hayward. Thomas Aldcorn; Finance Committee, E. S. Andress, J. H. Bailey, S. W. McMunn.

The removal of the meeting-room and the holding of meetings in the daytime were intended to suit the convenience of the many visiting railroad men who were unable to attend under the old conditions.

Northwest Railroad Club.—At the regular meeting in St. Paul, Minn., November 8, the first subject for discussion was Rigid and Swing-Beam Trucks, which was opened by a paper by Mr. J. C. Barber. On account of lack of time the discussion was not completed, but was continued until the next meeting.

The other subject was Locomotive Side-Rods, on which a paper was read by Mr. H. Higgins, which was discussed by a number of members present, the majority of whom, from their experience, favored the solid end rod. At the conclusion of the discussion a vote was taken which was in favor of the opinion that the solid-end rod is preferable to the strap-rod.

Western Railway Club.—At the regular monthly meeting in Chicago, November 18, the first subject was Steel-Tired Wheels and Tire Fastenings. The paper presented by Mr. Rhodes at the October meeting was discussed at considerable length.

The next subject was Swing-Beam and Rigid Trucks, on which Mr. Durrell, of the Illinois Central, presented some data.

Mr. C. A. Shroyer read a paper on Draft Rigging, which was discussed by members present.

Engineers' Club of Philadelphia.—At the regular meeting, October 4, the Secretary presented a correspondence with regard to the participation by the Club in the proposed International Congress of Engineers to be held during the coming World's Fair at Chicago, and moved that a committee of three, to consist of the President and two other members to be named by him, should be appointed to take up this subject so far as this Club is concerned. It was so ordered.

At the regular meeting, October 18, with reference to the International Congress of Engineers, the President stated that he had appointed Messrs. Wilfred Lewis and E. V. d'Invilliers as the members of the committee referred to.

The Secretary presented, for Mr. Robert A. Cummings, a photograph and description illustrating the effect of gases from locomotive stacks upon vegetation.

Mr. Arthur Falkenau presented an extensively illustrated description of a new Method of Making Barrels by Machinery. The drawings illustrating this description are of so elaborate a character that it would be impossible to give a comprehensive abstract.

There was considerable discussion of this subject, principally by Messrs. Henry G. Morris, Wilfred Lewis, John C. Trautwine, Jr., Max Livingston, and the author.

At the regular meeting, November 1, the Committee representing the Club in relation to the proposed Congress of Engineers in Chicago made a report, with the recommendation that the Club should agree to meet its share of the expenses, the necessary amount to be raised by subscription.

Mr. Benjamin Franklin presented a paper upon the Application of Drain Tiling to the Improvement of Ground for Residences.

There was some discussion of this paper. Mr. Howard Murphy noted a case where drain tiling had been used by him around a private residence in order to relieve the flooding and dampness in the cellar.

The Secretary presented, for Mr. Harvey Linton, a paper upon Topographical Surveying, with photographic illustrations.

Engineers' Society of Western Pennsylvania.—The regular meeting, October 21, was the first held by the Society in its new quarters in the Thaw Mansion. W. J. McFarland, James Foster, George H. Hodginson, and Charles F. Wieland were elected members. Thanks were voted to several visiting members of the Iron & Steel Institute for drawings, specimens, etc., presented.

Professor John W. Langley read a paper on European Bessemer Practice in Small Converters, giving his observations made during a trip abroad.

Engineers' Club of Cincinnati.—At the regular November meeting, the Secretary announced the death of Charles L. Jungerman, a member, and a committee was appointed to prepare suitable resolutions.

Mr. J. C. Lemon read a very interesting paper on Cast Iron Water Pipes, which was discussed by members present.

Engineering Association of the Southwest.—The annual meeting was held in Nashville, Tenn., November 13, when reports were presented showing that the Association was in good condition, and had made excellent progress during its first year. A number of candidates were elected to membership, and an address was made by the President, Colonel John McLeod.

Civil Engineers' Club of Cleveland.—At the regular meeting, November 11, James Wallace Kelly and Frank Walter Wilson were elected active members. Mr. Eisenmann reported the action of the committee at Chicago appointed to formulate a plan for an International Congress of Engineers.

Professor Harry Fielding Reid gave a paper on the Muir Glacier. Dr. Reid conducted an exploring party to Alaska this last summer, and he gave a very interesting description of this glacier, which covers an area of 1,000 square miles, flowing in two opposite directions, and having two termini, one at tidewater and the other several hundred feet higher. The lower, 1½ miles wide, terminus is about 250 ft. above the water, and extends an unknown depth into the water, which has been sounded to the depth of about 1,000 ft. From this terminus immense masses of ice are continually breaking off, falling into the water and floating away as icebergs. One most remarkable phenomenon was observed, the existence of a central moraine extending from end to end, moving in two opposite directions and apparently having no beginning. Its like has never before been observed. After much difficulty the velocity at the lower end was found to be 8 or 10 ft. per day, and the upper end probably between 2 and 3 ft. The belief is that the glacier is receding, and to determine this permanent stations have been established from which observations will in the future be made, and other means taken to ascertain whether or not one part is not what is called a dead glacier. The ice was observed to have different colors, depending on the amount of sunlight it had been exposed to. The glacier has several lateral branches with different names, one of which is the White Glacier from the whiteness of its ice.

At the conclusion there was an interesting discussion of a number of the remarkable phenomena observed.

Western Society of Engineers.—At the regular meeting, October 1, the following members were elected: Charles E. Hopkins, Charles V. Weston, Theodore Starrett, Jacob A. Harman, Henry E. Gamble, Ira Smith Dunning, L. C. B. Holmboe, Charles J. Morse, William E. Miller, Ridley H. Lawrence, Harold A. Boedker.

Reports were received from the committees on Reception of the Iron and Steel Institute; on the Chicago Railroad Problem, and on Bridge Legislation, all reporting progress.

Mr. Isham Randolph read an interesting paper on Railroad Signaling and Interlocking, which was discussed at length by members present. Mr. Hansel, Consulting Engineer of the Illinois Railroad Commission, made some interesting statements as to the measures taken by that Commission to require improved signals at grade crossings, and stating the progress which had been made in that direction.

Montana Society of Civil Engineers.—At the regular monthly meeting in Helena, Mont., on October 18, correspondence with the Western Society of Engineers in relation to an International Congress of Engineers, to meet in Chicago during the World's Fair, was submitted. Correspondence with the Engineers' Club of St. Louis and a letter of thanks from Honorable T. H. Carter were also submitted. Amendments to the articles of association of engineering societies previously submitted were approved.

It was resolved that a committee of three be appointed to frame a bill for the protection of life from open mine shafts and prospect holes, and to present the same to the Montana Legislature at its next session. Messrs. Keerl, Hovey, and McRae were appointed such committee.

NOTES AND NEWS.

Worshiping the Locomotive.—In a foot-note to an article by Mr. Gladstone on Mr. Carnegie's "Gospel of Wealth," published in a recent number of the *Nineteenth Century*, in London, in speaking of objects of worship the distinguished author says: "I understand that in some remote districts of India, where school-training has not penetrated, the locomotive has been seen to receive offerings of cocoanuts and flowers."

Railroads Needed in Africa.—To make the great system of inland waterways easily accessible to commercial exploitation from without would require a system of railroads aggregating, perhaps, 2,000 miles in length. The chief lines would be around the Livingstone Cataracts, on the Congo, from Vivi to Stanley Pool; a line from the coast to the Upper Niger; the long talked-of line from Suakim to Berber, and a line 500 miles long from Mombasa to the Victoria Nyanza. These four lines would absorb about 1,400 miles of the 2,000 estimate. Minor lines would connect Lakes Nyassa and Tanganyika, take the place of the Stewart Road around the Murchison Cataracts, on the Shirè, and overcome the difficulties at such points as Stanley Falls, and the cataracts of the Upper Nile system. A length of 40 miles would be required on the Shirè, a dozen miles at Lahore, and at various points lengths of railroad varying from near 200 miles between Nyassa and Tanganyika to a couple of miles around some of the lesser cataracts. The estimated cost of this comprehensive system of small, isolated railroads is, roughly, $50,000,000.—*Thomas Stevens, in Scribner's Magazine for September.*

The Pike's Peak Railroad.—This line, from Manitou, Col., to the summit of Pike's Peak, is a rack-railroad on the Abt plan, which has been heretofore described in our columns. Its length is 46,158 ft., or 8.74 miles. The altitude of its station at Manitou is 6,600 ft.; at the summit it is 14,200 ft. above sea-level, the total ascent being 7,600 ft., or an average of 846 ft. per mile. The maximum grade is 25 per cent., over 22 per cent. of the line having a grade of from 22½ to 25 per cent. Of straight line there is 28,378 ft., and of curved 18,477 ft., about 39 per cent. of the line being on curves. The sharpest curves are 16°, of which there are many. The road-bed foundations are firmly secured, and further protected and sustained by wide embankments wherever practicable. There are four iron bridges—two of 20 ft. and two of 30 ft. span, resting on masonry abutments

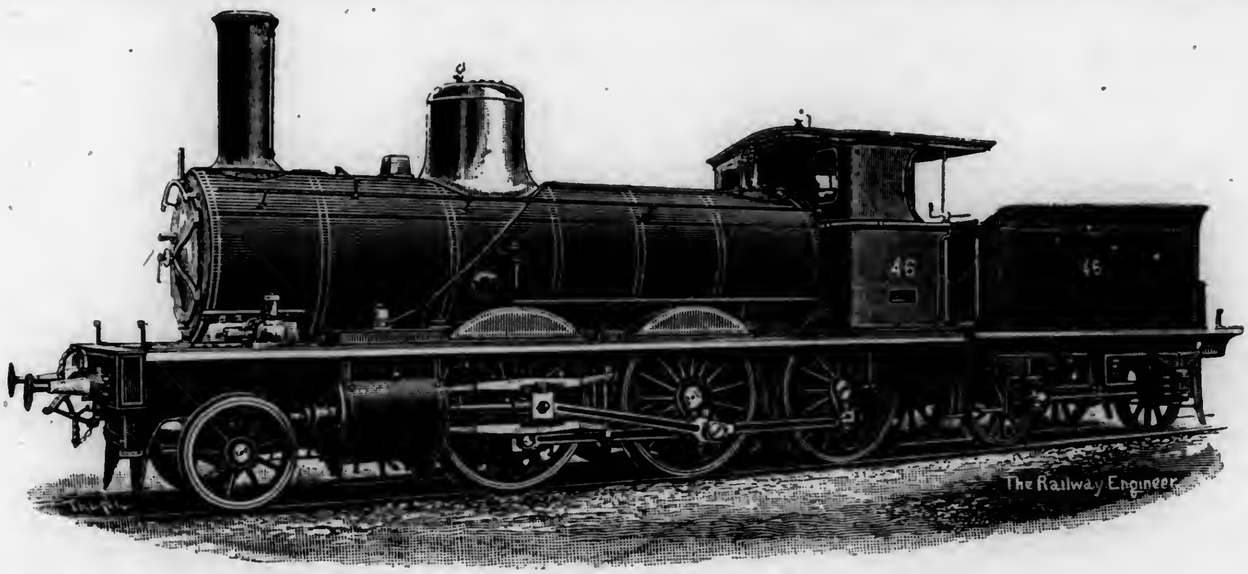
The three locomotives, which were built at the Baldwin Works, in Philadelphia, weigh 25 tons each. They are carried on six bearing-wheels, and there are two driving-wheels engaging with the rack-rail. The cylinders act upon a drum placed directly over the rear driver, and the forward driver is connected by parallel rods.

The brake apparatus is especially powerful. On either side of the pinions is a corrugated surface against which a steam-brake presses with great force. The engine is also fitted with hand-brakes and the Le Chatelier water-brake, by which the cylinders act as brakes. One engine will push two cars weighing 42,000 lbs. loaded. The average speed will be five miles an hour. The cars are not tilted, but the seats are so arranged as to give the passengers a level footing. The engine, instead of drawing, pushes the cars. The cars can also be let down hill independent of the engine, if necessary.

A Railroad Church.—Bishop W. D. Walker, of the Episcopal Church in North Dakota, has had a special car fitted up as a traveling church, in which he makes his visitations through his extensive diocese. The car goes from point to point, is run on a siding wherever the Bishop means to stop, and is used at all the points—still numerous—where there are no regular houses of worship. It is fitted up neatly inside, and will hold a congregation of some size.

The idea may be original with Bishop Walker, but the Russians used it a year or two ago, and have a traveling church and also a traveling school-house, which visit periodically the way stations on the Trans-Caspian Railroad.

A Swiss Compound Locomotive.—The accompanying illustration, from the *Railway Engineer*, shows a compound locomotive built by the Société Suisse at Winterthur for the Jura-Berne-Lucerne Railroad. The engine is on the Von Borries system, with one high-pressure and one low-pressure cylinder. The cylinders are outside, and have the steam-chests on top, the valve motion, which is an ordinary link motion, being inside; the valves are worked from a rocker shaft, in a manner similar to that generally in use in this country.



The high-pressure cylinder is 16.7 in. and the low-pressure 25.2 in. in diameter, both being 25.6 in. stroke. The grate area is 16.15 sq. ft.; the heating surface is: Fire-box, 80.7; tubes, 1,223.9; total, 1,304.6 sq. ft. The driving wheels are 59.8 in. in diameter; the leading and trailing wheels are 36.6 in., and the leading axle is carried in radial axle boxes.

The engine weighs 94,800 lbs. in working order. The tender carries 1,570 gallons of water and 9,250 lbs. coal, and weighs 46,300 lbs. when fully loaded.

The volumes of the two cylinders have a ratio of about 1 to 2. The valve motion is arranged so as to equalize as much as possible the work done by the steam in the two cylinders. In the Von Borries' system this end is attained by giving different lengths to the levers from which the links are hung. In the engine in question the degrees for admission in the two cylinders when in forward gear are:

High-pressure, 13, 20, 31, 41, 51, 60 and 76 per cent.

Low-pressure, 20, 29, 42, 51, 59, 66 and 80 per cent.

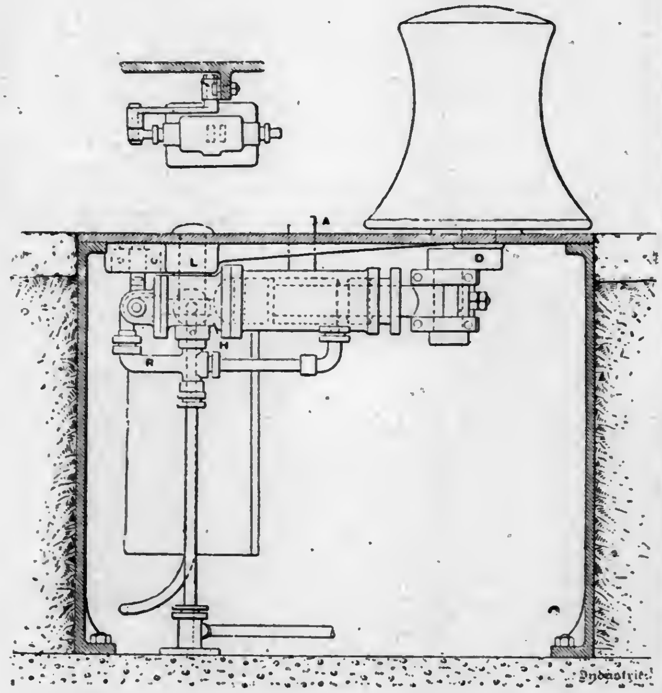
The Westinghouse brake is fitted to the four rear driving wheels. A sanding apparatus is provided, and also an injector for washing the rails.

Transmission of Power by Electricity.—Siemens pointed out that no further loss of power was involved in the transformation of electrical into mechanical energy than is due to friction, and to the heating of the conducting wires by the resistance they oppose, and showed that this loss, calculated upon data arrived at by Dr. John Hopkinson and by himself, amounted at the outside to 38 per cent. of the total energy. Subsequent careful researches by the Brothers Hopkinson have demonstrated that the actual loss is now much less than it was computed at in 1885; as much as 87 per cent. of the total energy transmitted being realizable at a distance, provided there be no loss in the connecting leads used.

Hydraulic Capstan Engine.—The accompanying illustrations represent Gallon & Chapman's patent hydraulic engine for working capstans or other machinery, as applied to two capstans at the Albert Dock, Leith, fig. 2 being an elevation and fig. 3 a plan. The engine was built by Hawthorne & Company, Leith, Scotland.

It consists of two double-acting oscillating cylinders *C C*, placed at about right angles to each other, with piston-rods *E E*, attached direct to a single crank *D*, of which the pin is long, with a gun-metal bearing. The cylinders are lined with brass, and oscillate through a few degrees only, the oscillating block *H* being carried by two long bearing-pins *L*, which pass

Fig. 1. Fig. 2.



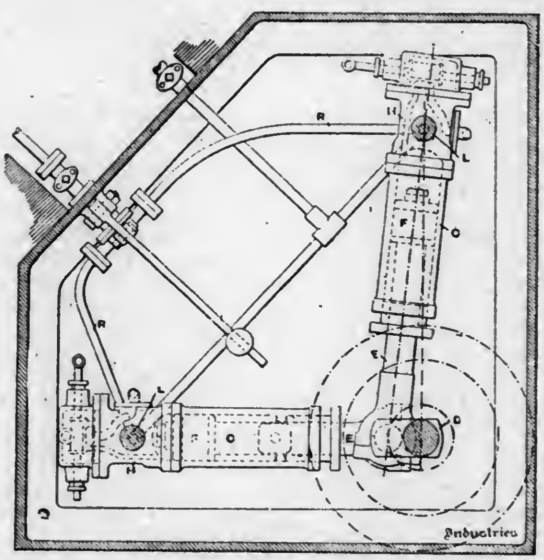


Fig. 3.

through bosses on the bed-plate. The pistons *F F* are fitted with hemp in preference to leather packing. The slide-valves and faces are of extra hard gun-metal, the valves being controlled by a single or double link so that they cannot be displaced. Fig. 1 shows a detailed view of the slide-valve link. The main pressure-pipes *R R R* oscillate slightly when they are packed by means of a stuffing-box and gland, ample space being provided to permit of the operation of packing. The starting is effected by means of a lever *A*, placed so as to be readily worked by the operator, and an adjustment arrangement is provided to regulate the speed of the capstan. The fewness of working parts and their simplicity ensure continuity of work with minimum attention and overhauling. In fact, one of these engines and capstans has been successfully at work for upward of two years.—*Industries.*

The Work of the Naval Engineer.—The *Spectator* has an article headed "What Our Naval Engineer Must Do," which seems to be suggested by a recent correspondence in the *St. James's Gazette*. The writer points out that whereas a ship like the *Rattlesnake* has five lieutenants and one sub-lieutenant, she has only one engineer officer, which, it is argued, is by no means sufficient. When anything goes wrong with the machinery or gear, the solitary engineer officer has to spend very many hours on duty, although when things have settled down he may, if he likes, leave the supervision to an "artificer," who is paid £2 a week to take command of the engines of a ship which cost £200,000. He has the permission of the late Second Naval Lord for doing this, and that high authority has expressed himself "perfectly satisfied" with the arrangement; so he has no right to be critical. At the same time, he naturally feels uneasy at leaving to a workingman the charge of engines of 3,000 H.P., together with the pumping engines, and the electric-light engines, and those for hoisting in the boats, with the steam-steering gear and the two steam pinnaces, in addition to a "watching brief" for guns large and small, which the men can put out of order at the "shortest notice" and "the least possible delay." Yet these are by no means a full list of what were described before the Committee on Naval Estimates as "the comparatively simple duties of an engineer officer."

Geographic Names.—The Board on Geographic Names, appointed by the heads of departments in Washington, has been formally constituted by the following order from the President:

"As it is desirable that uniform usage in regard to geographic nomenclature and orthography obtain throughout the Executive Departments of the Government, and particularly upon the maps and charts issued by the various departments and bureaus, I hereby constitute a Board on Geographic Names, and designate the following persons, who have heretofore co-operated for a similar purpose under the authority of the several departments, bureaus and institutions with which they are connected, as members of said Board: Professor Thomas C. Mendenhall, U. S. Coast and Geodetic Survey, Chairman; Andrew H. Allen, Department of State; Captain Henry L. Howison, U. S. N., Lighthouse Board, Treasury Department; Captain Thomas Turtle, Engineer Corps, War Department; Lieutenant Richardson Clover, U. S. N., Hydrographic Office, Navy Department; Pierson H. Bristow, Post Office Department; Otis T. Mason, Smithsonian Institution; Herbert G. Ogden, U. S. Coast and Geodetic Survey; Henry Gannett and Marcus Baker, U. S. Geological Survey.

"To this Board shall be referred all unsettled questions concerning geographic names, which arise in the Executive Departments, and the decisions of the Board are to be accepted as the standard authority in such matters.

"Department officers are instructed to afford such assistance as may be proper to carry on the work of this Board.

"The members of the Board shall serve without additional compensation, and its organization shall entail no expense upon the Government."

Lieutenant Richardson Clover, U. S. N., has been chosen Secretary of the Board, and all communications intended to reach it should be addressed to him.

Influence of the Rotation of the Earth on Moving Bodies.—In an article published in the *Zeitschrift* of the German Engineers' Union, Herr T. Von Bavier says that it has often been observed that in railroad lines running north and south there occurs, in course of time, an appreciable displacement of the rails, always more noticeable on the right-hand side. This is, as the author remarks, chiefly due to the effect of the rotation of the earth on its axis, the normal condition being that with a train traveling in such a direction and equally loaded there is a greater pressure on the right-hand side than on the left.

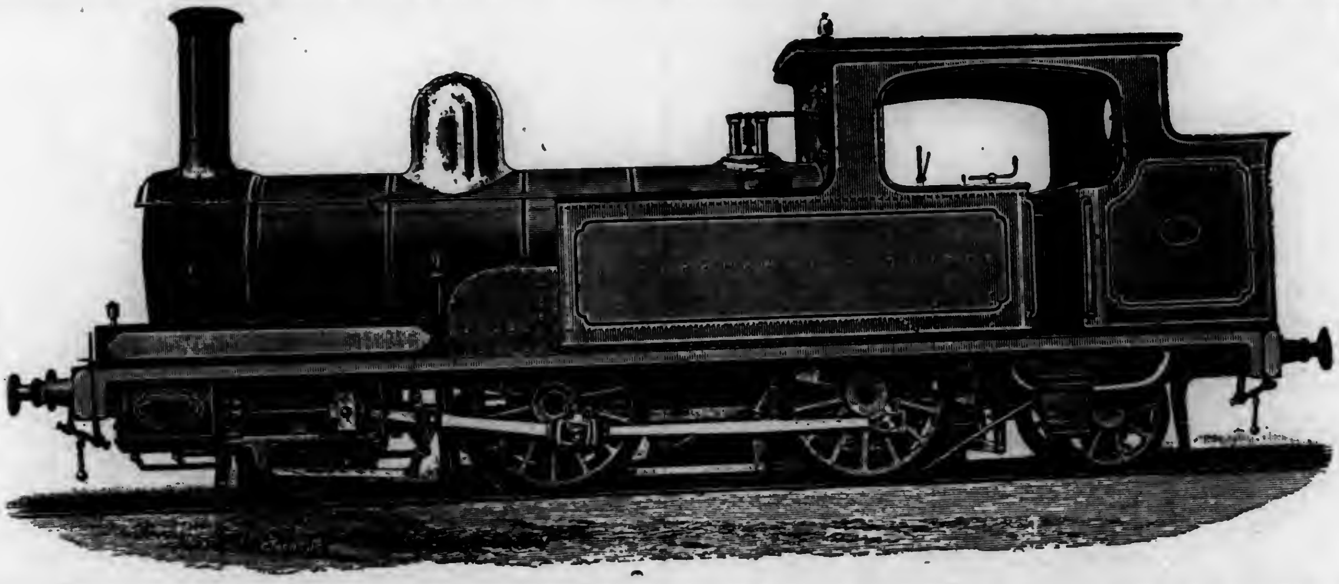
In N. latitude 51° a man weighing 165 lbs., running at the rate of 13 ft. per second from north to south, sustains a horizontal pressure toward the east equal to 54 grains, which, acting at the center of gravity of the body at say 3 ft. 3 in. above the ground, necessitates an extra pressure on the right foot of 0.63 oz., in order to maintain the vertical position of the body. In going from south to north the proportion is the same; in the southern hemisphere the extra pressure would come on the left side. With varying directions the force is, of course, proportionately varied.

In the case of an express train, weighing say 400 tons, traveling northward at the rate of 50 miles an hour, the extra pressure on the right-band or eastern rail amounts to 501 lbs., the same

pressure coming on the right-hand or western rail when traveling in the reverse direction. In more northerly parts the lateral force increases, reaching its maximum at the North Pole, in which region, in a case similar to the preceding, the extra pressure on the right-hand side would be 660 lbs. In the large ocean steamers the force is considerably greater; the side-pressure on the Inman liner *City of New York* being about 936 lbs. The tendency of this lateral pressure would be to drive the vessel (if on a northward or southward course) somewhat to the east, so that to keep on a prescribed course requires a slightly increased engine power to overcome the tendency to deviation. This increase is, however, not more than $\frac{1}{1000}$. Such as it is, it is inappreciable on the east and west run between Liverpool and New York; but would be distinctly perceptible in a voyage from Liverpool to Buenos Ayres.

A Tank Locomotive for Japan.—The accompanying illustration shows a tank locomotive built for the Sanyo Railroad in Japan by the Vulcan Foundry Company, of Newton-le-Willows, England; it is from the London *Railway Engineer*.

The engine has four coupled wheels, with bearing wheels in front and behind the fire-box, the bearing axles being fitted with radial axle-boxes. Water is carried in two side tanks and a smallr ear tank, and coal in a box placed on an extension of the frames behind the fire-box. The tanks have a capacity of 1,000 gallons of water, and the coal-box 45 sq. ft.



The gauge of the engine is 3 ft. 6 in. The driving wheels are 52 in. in diameter, and the leading and trailing wheels are 37 in. The cylinders are 14 in. in diameter and 20 in. stroke; they are placed outside and have the steam-chests on top. The valves are worked by Joy's valve gear, placed outside, as shown in the engraving. The grate area is 12 sq. ft., and the heating surface is: Fire-box, 70; tubes, 654; total, 724 sq. ft.

The total weight of the engine in working order is 78,400 lbs. It is fitted with driver brakes. The cab is of sheet iron and has a double front, as shown, the engine being intended to run in either direction, without turning.

The Transandine Railroad.—The originators of this line are J. E. & M. Clark & Company, who obtained in 1873 the first concession of a line from Buenos Ayres to the Pacific, passing through Villa Mercedes, Mendoza, and through the Uspallata Pass to the Chilian frontier, with a branch from Mendoza to San Juan. Owing to financial and political difficulties, this general combination was not carried out. About 1880 the Argentine Government built the section from Villa Mercedes to Mendoza and San Juan. In 1883 Clark & Company built the Pacific line from Buenos Ayres to Villa Mercedes, which has since passed into the hands of an English company, while the line from Villa Mercedes to Mendoza has also become the property of an English company, the Argentine Great Western. The actual works of the Transandine line were begun in 1887 by an English syndicate called the Buenos Ayres & Valparaiso Transandine Railway Company, which bought the concession from Clark & Company, and is building the line on the Argentine side, with Clark & Company as contractors. On the Chili side, from Los Andes to the frontier, the line is being built by Clark & Company, under the title of Clark's Transandine Railway. Thus, when the route is finished, it will run over the rails of five different companies between Buenos Ayres and Valparaiso, namely, the Pacific, the Argentine Great Western, the Buenos Ayres & Valparaiso Transandine, Clark's Transandine, and lastly the Chilian State line, from Los Andes to Valparaiso

The first studies for the mountain line were made in 1873, but a serious survey was not completed until 1887, amid countless difficulties, for the ground was almost entirely pathless and unknown both geographically and geologically. Up to the present day you find no maps and no literature about this section of the Andes. The field is new and open to future enterprise. The point at which the Cordillera is to be passed is situated in the Cumbre between the two lofty snow-clad peaks of Tupungato toward the south and Aconcagua toward the north. From the Chili side the line winds along the terraced mountains of the valley of the Aconcagua River; from the Argentine side the valleys of the Mendoza and Cuevas rivers are followed amid innumerable obstacles, owing to the capricious course of the streams, the interruption caused by loose pebbly earth, or *ripio*, by masses of gravel carried down by the lateral torrents and piled up in cones, and by *barrancas*, which are vertical or sloping banks of gravel apparently deposited in times past by the rivers.

In order fully to realize the natural difficulties of this great Transandine enterprise, one must have been over the ground, examined the peculiar dangers due to landslips, torrents, and avalanches, and passed through the silent region of eternal snows which the line avoids by burying itself in the bowels of the earth. One must have seen, too, the mountain-side dotted with long strings of pack-mules, laden with timber, iron, bricks, and even with their own fodder, for everything used in the construction of the line hitherto has been brought by thousands of mules either from Mendoza or Los Andes. However, now the works are beginning to become easier. The rails are being laid more rapidly. This year the track will be available up to Uspallata. In 1891 the station of Punta de las Vacas will be opened to the public; while on the Chili side the line will be ready for traffic as far as Juncal at the same date, and thus the mule journey will be reduced to a single day's ride. Finally, about 1895 we may hope to see the whole line in working order.

The business prospects of the line seem fair to those who have put money in the enterprise, the main element of income being expected from passenger traffic. At present, during the five summer months, there is an average of 25 passengers a day crossing in each direction. When the railway is open this number will increase perhaps tenfold. A second source of revenue will be local traffic and merchandise between Chili and the Argentine provinces of Mendoza, San Juan, and San Luis. A third element of profit is looked for in the transport of cattle from the Argentine to Chili. At present some 40,000 to 50,000 head are driven over yearly by the Uspallata Pass, and arrive in Chili mere skeletons. These cattle have to be fattened in Chilan *potreros*, where pasture is very dear; whereas, by the line, they can be carried over fattened and ready for killing. Fourthly, it is hoped that mines will be discovered and worked in the region opened up by the railroad. As for general merchandise and imported goods, the Transandine will not be able to compete with steamboat freights, and therefore the port of Valparaiso will retain all its importance.—*Theodore Child, in Harper's Magazine.*